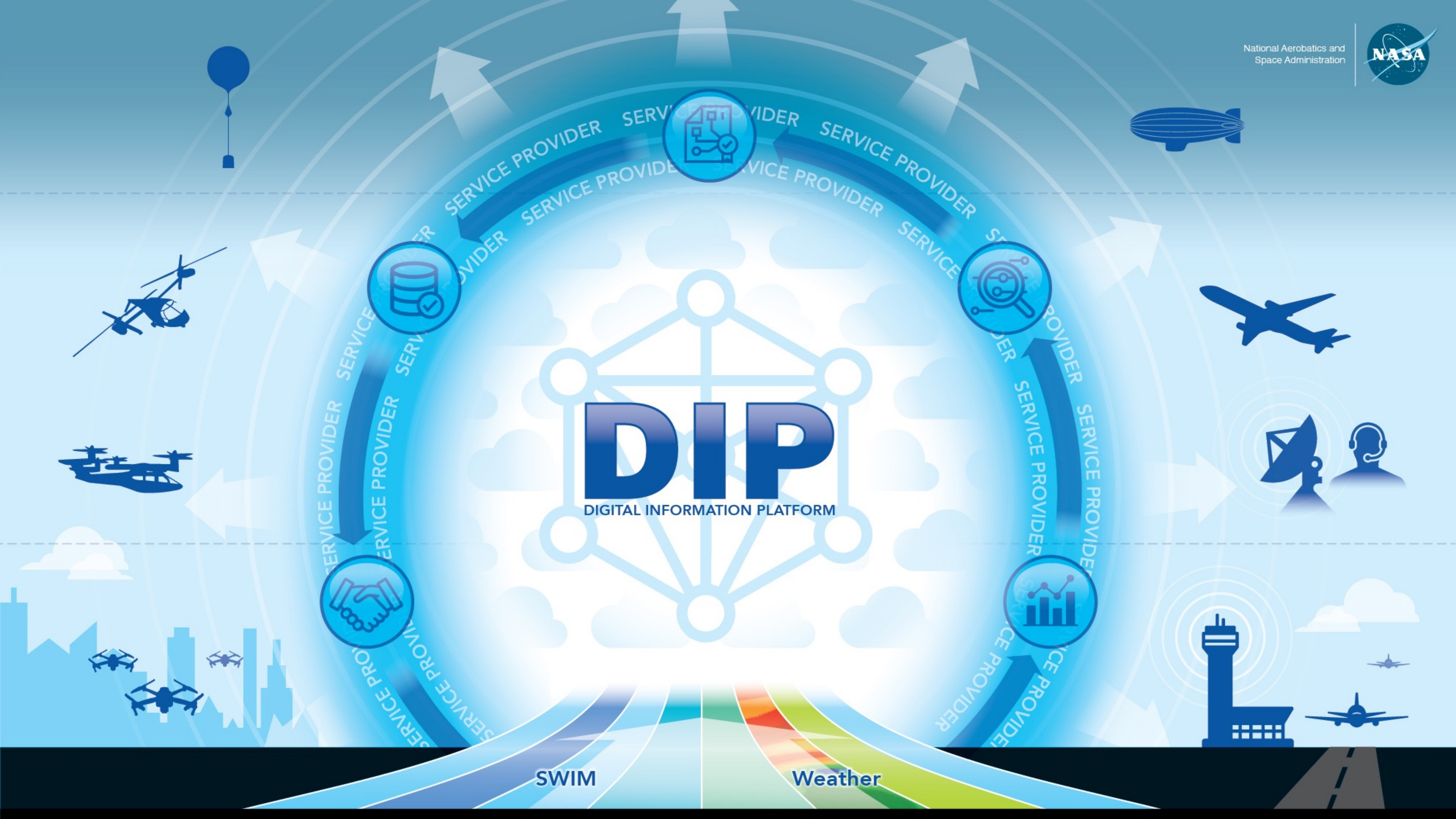
National Aerobatics and
Space Administration



DIP

DIGITAL INFORMATION PLATFORM

Ground Rules

- Please **turn off your mic and camera** (for bandwidth issue)
- There will be Q&A times throughout the session and at the end
  - Our questions for you posted in https://arc.cnf.io/sessions/nedn/#!/dashboard
  - You can post questions
    - in the same Conferences.io link or
    - in the MS Teams chat box
- Video recording & slides will be available on DIP website after the workshop
- There will be no break

DIP Workshop Series

- **Objectives**
  - – Obtain informed technical feedback to DIP design
  - – Prepare participants for what they could expect from upcoming demo events
- **Target Audience**
  - – Flight operators – traditional and new entrants
  - – Service and data providers
  - – Research organizations
- **Approach**
  - – Present DIP at a technical level
  - – Walk through the capability and ask prompting questions

DIP Workshop Series: #3
DIP for Consumers

February 23, 2022

Agenda

- DIP features for consumers
- Use cases with showcase demo
  - NASA data integration services
  - NASA developed machine learning services
  - Example of User Interface: CDDR webpage on live system
- Performance metrics – accuracy
- Technical development plan and schedule
- Q&A
- Next step & closing remarks

DIP Features for Consumers

Pallavi Hegde
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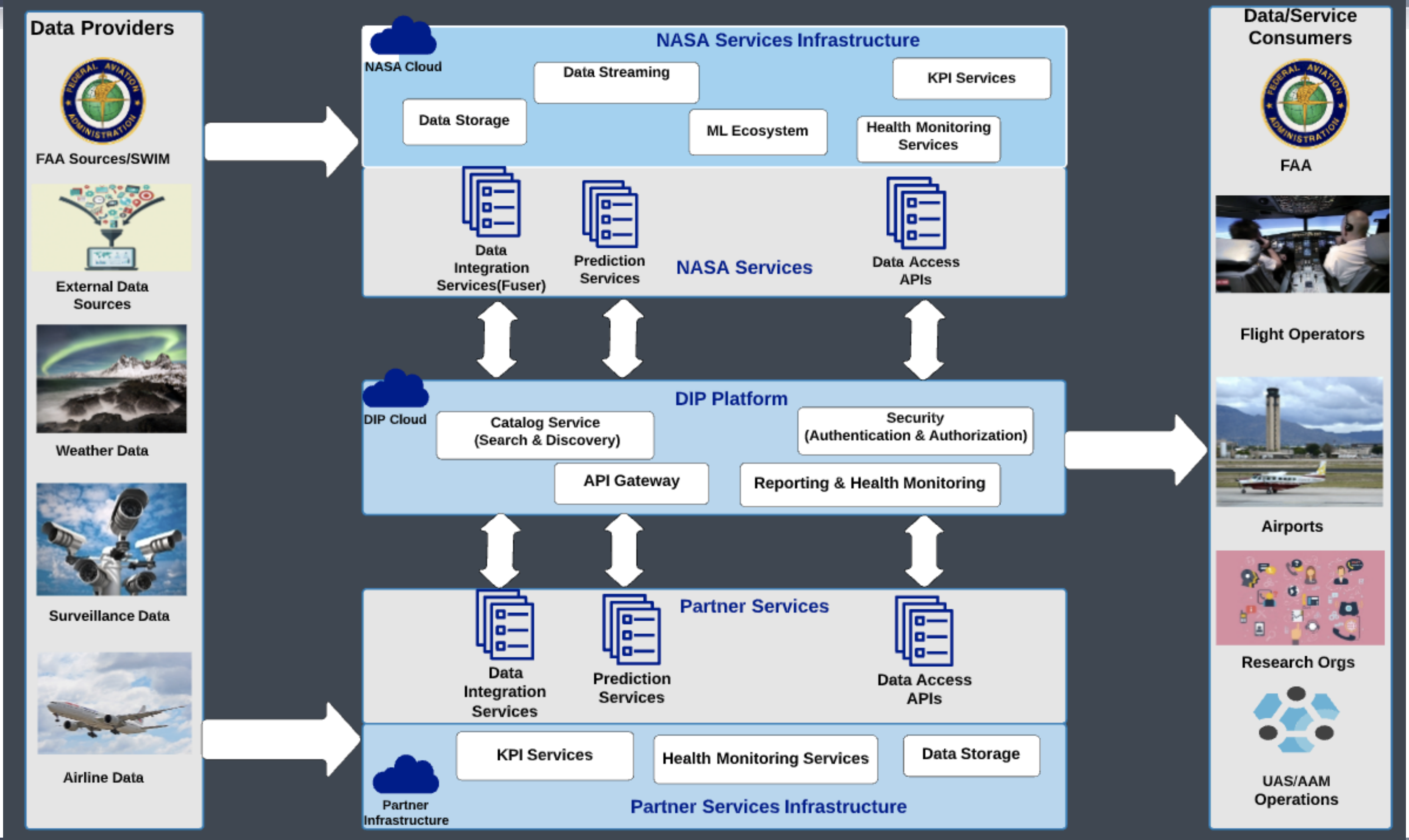
DIP Platform Functional Architecture


Data Providers

FAA Sources/SWIM

External Data Sources

Weather Data

Surveillance Data

Airline Data

NASA Services Infrastructure

NASA Cloud

Data Streaming

KPI Services

Data Storage

ML Ecosystem

Health Monitoring Services

Data Integration Services(Fuser)

Prediction Services

NASA Services

Data Access APIs

DIP Platform

DIP Cloud

Catalog Service (Search & Discovery)

Security (Authentication & Authorization)

API Gateway

Reporting & Health Monitoring

Partner Services

Data Integration Services

Prediction Services

Data Access APIs

KPI Services

Health Monitoring Services

Data Storage

Partner Infrastructure

Partner Services Infrastructure

Data/Service Consumers

FAA

Flight Operators

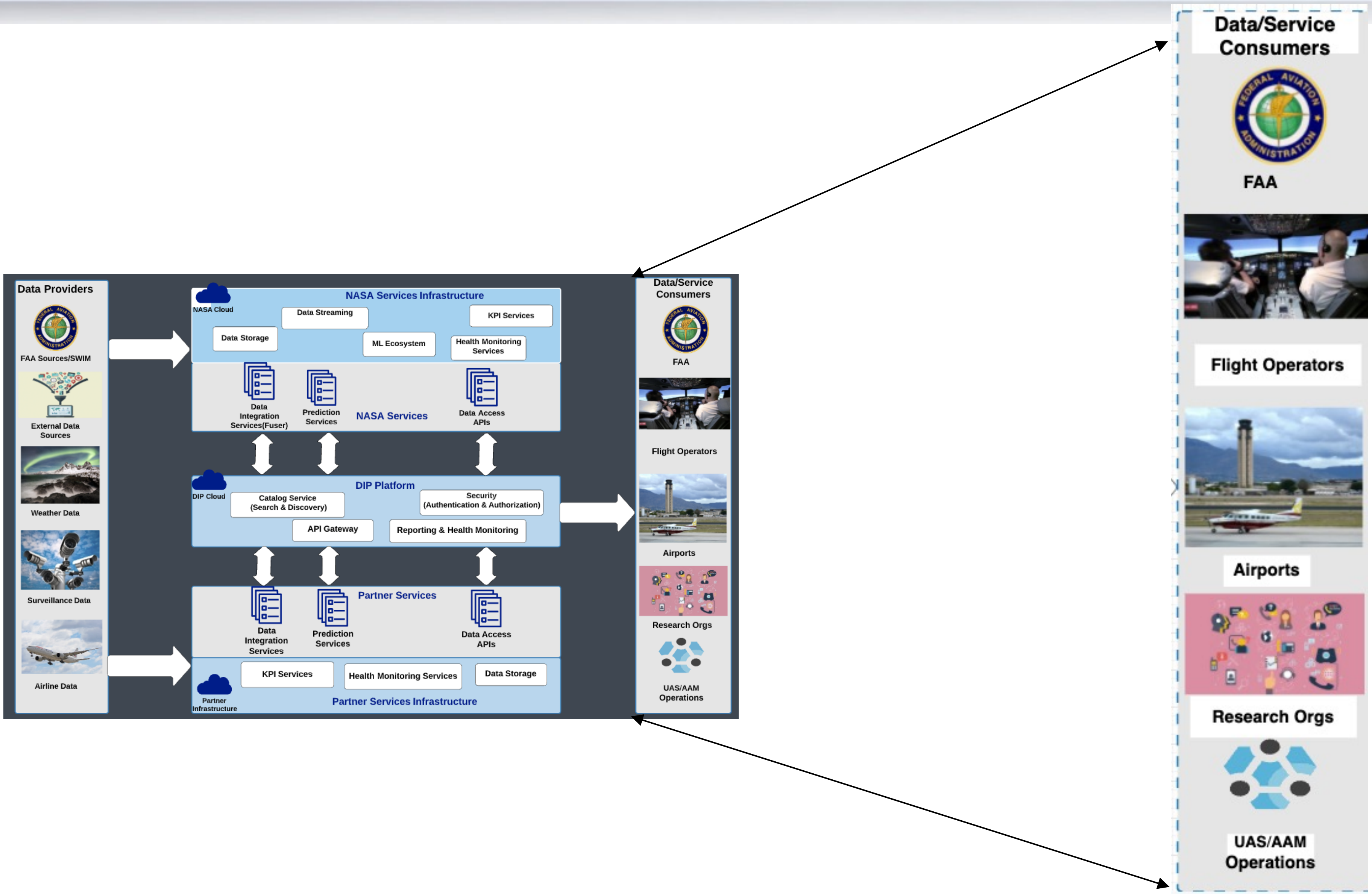
Airports

Research Orgs

UAS/AAM Operations

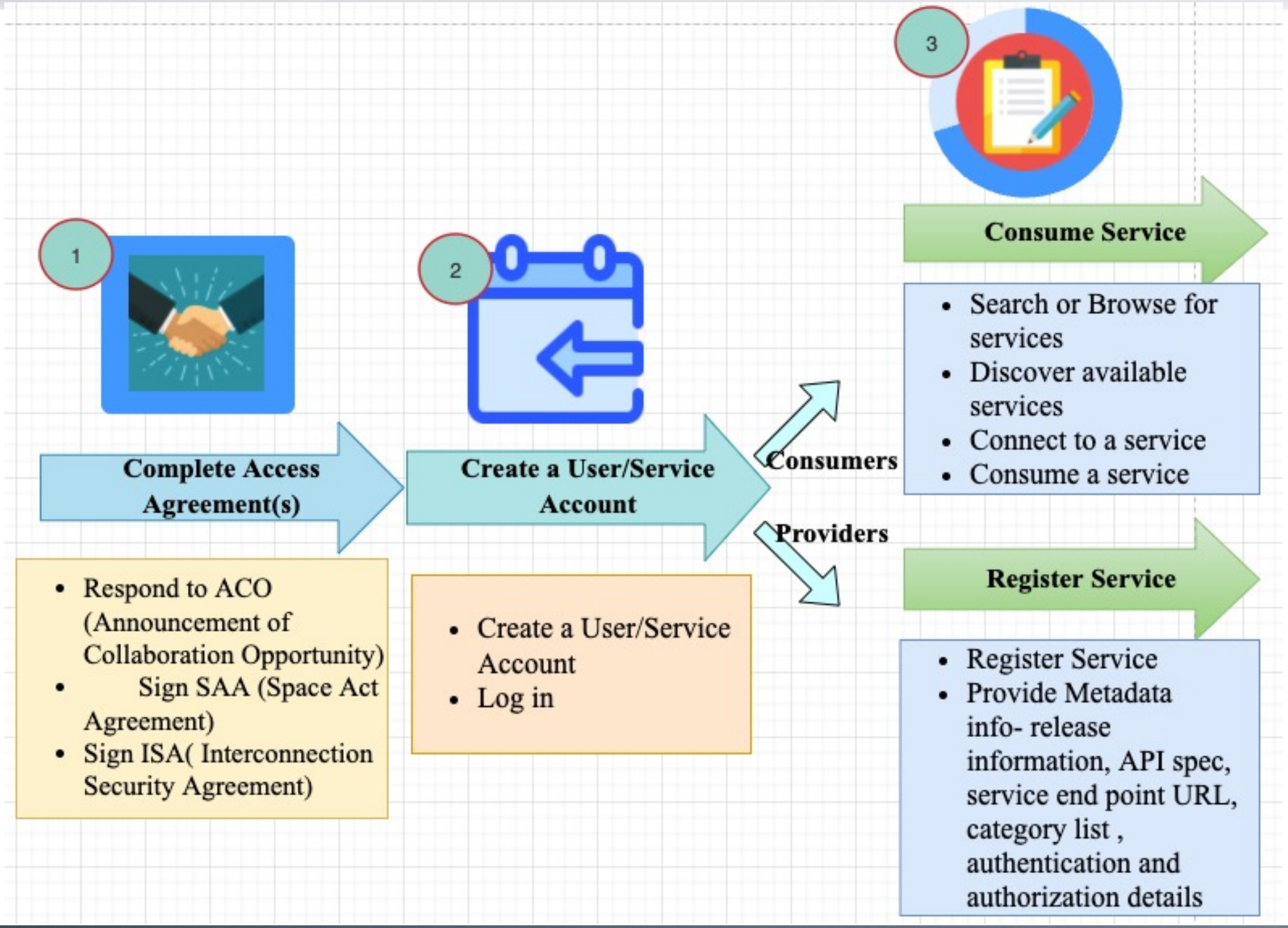
Common, simplified interface to integrated, processed information

Who are the Consumers



- FAA
- Flight Operators
- Airports
- Research Orgs
- UAS/UAM Operations
- Industry

Onboarding Services (Providers + Consumers)



Complete Access Agreement(s)

- Respond to ACO (Announcement of Collaboration Opportunity)
- Sign SAA (Space Act Agreement)
- Sign ISA(Interconnection Security Agreement)

Create a User/Service Account

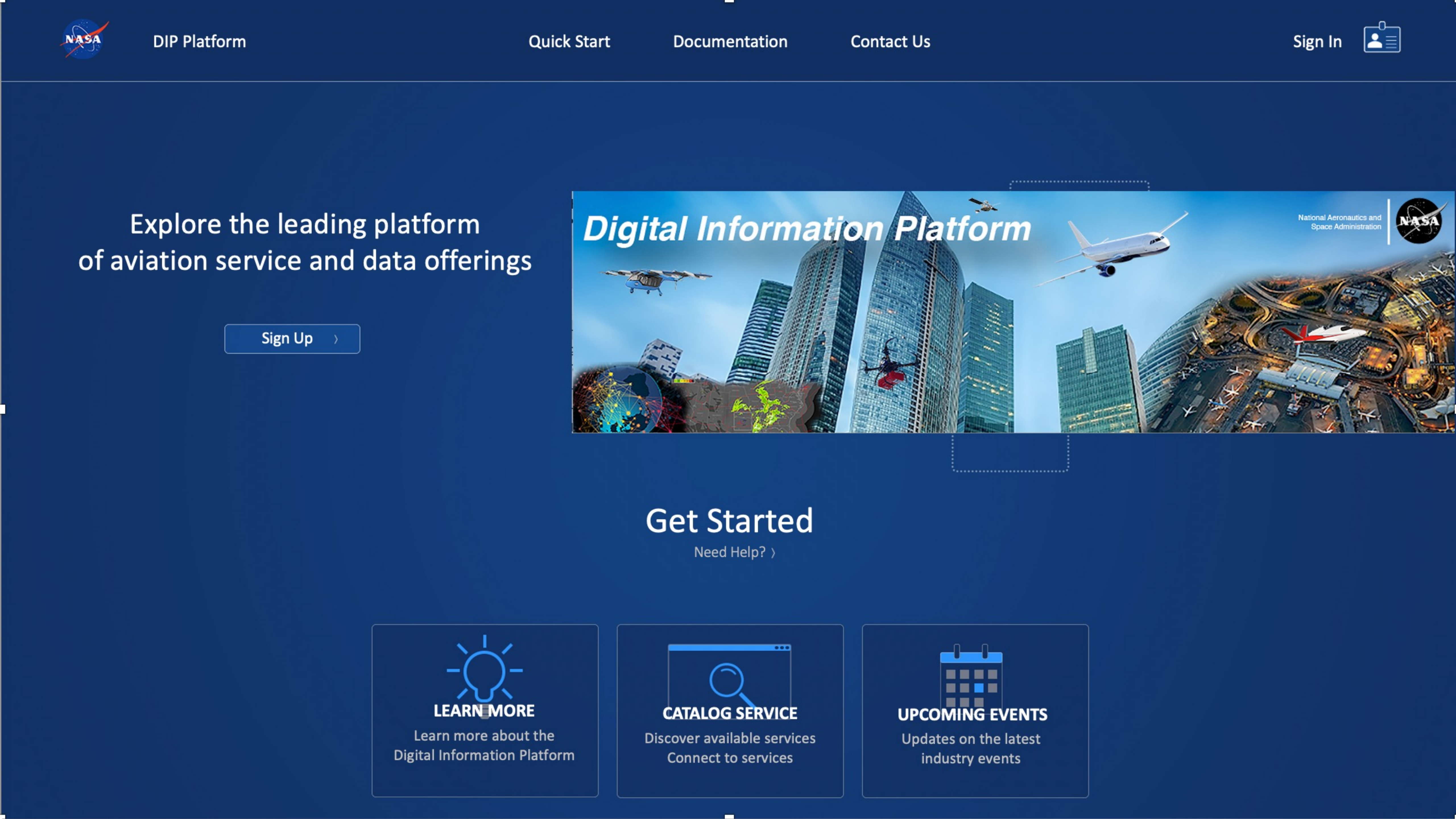
- Create a User/Service Account
- Log in

Consume Service

- Search or Browse for services
- Discover available services
- Connect to a service
- Consume a service

Register Service

- Register Service
- Provide Metadata info- release information, API spec, service end point URL, category list , authentication and authorization details



DIP Platform

Quick Start

Documentation

Contact Us

Sign In

Explore the leading platform
of aviation service and data offerings

Sign Up ›

Digital Information Platform

National Aeronautics and
Space Administration

Get Started

Need Help? ›

LEARN MORE

Learn more about the
Digital Information Platform

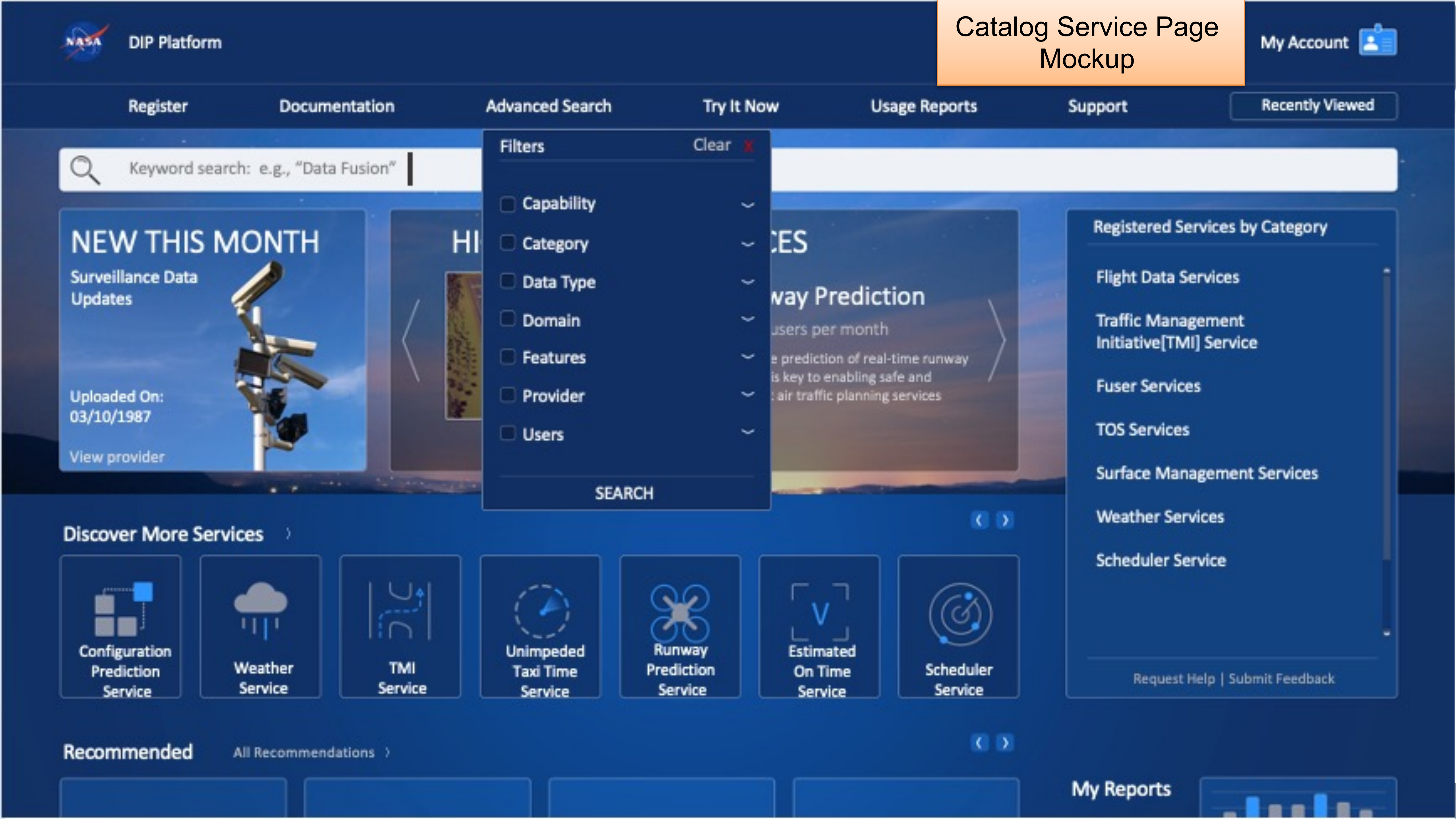
CATALOG SERVICE

Discover available services
Connect to services

UPCOMING EVENTS

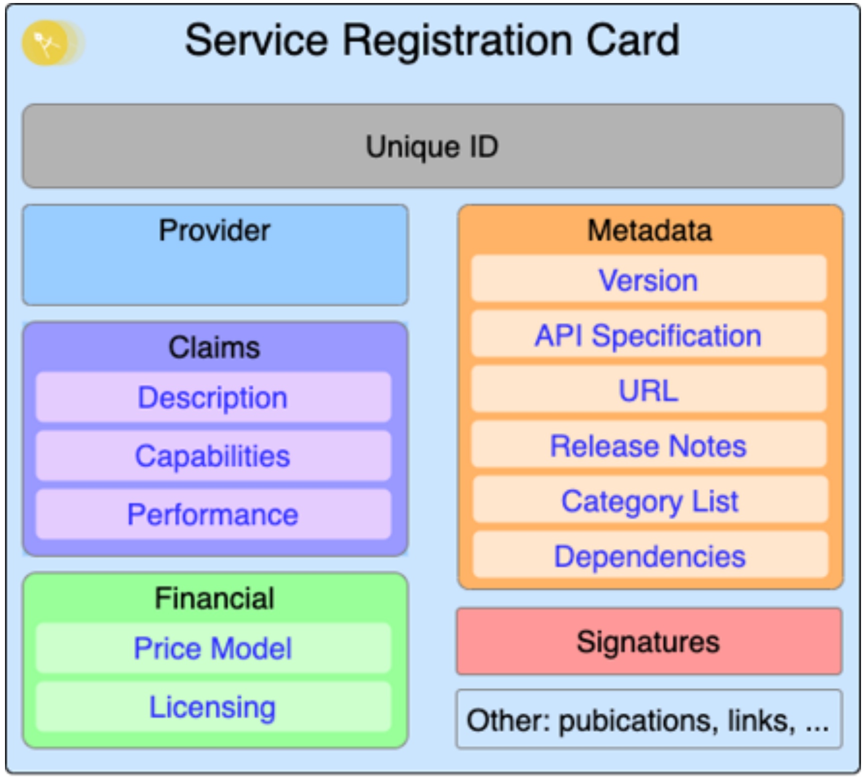
Updates on the latest
industry events

Catalog Service Page Mockup



e prediction of real-time runway
is key to enabling safe and
air traffic planning services

Service Information for Consumers



Service Registration Card

Unique ID

Provider

Claims

Description

Capabilities

Performance

Financial

Price Model

Licensing

Metadata

Version

API Specification

URL

Release Notes

Category List

Dependencies

Signatures

Other: pubications, links, ...

Consumers might be interested in:

- Information about the Service Provider
- **Claims about the service**: features, capabilities, performance, etc.
- **Financial Information**: what a consumer can expect in terms of cost of usage
- **Metadata**: release information, API spec, service end point URL, category list, service and data dependencies, other requirements need for access
- **Search key fields** : for discovering the right service to use

NASA will discuss with partners about additional information to be included in the service registration card

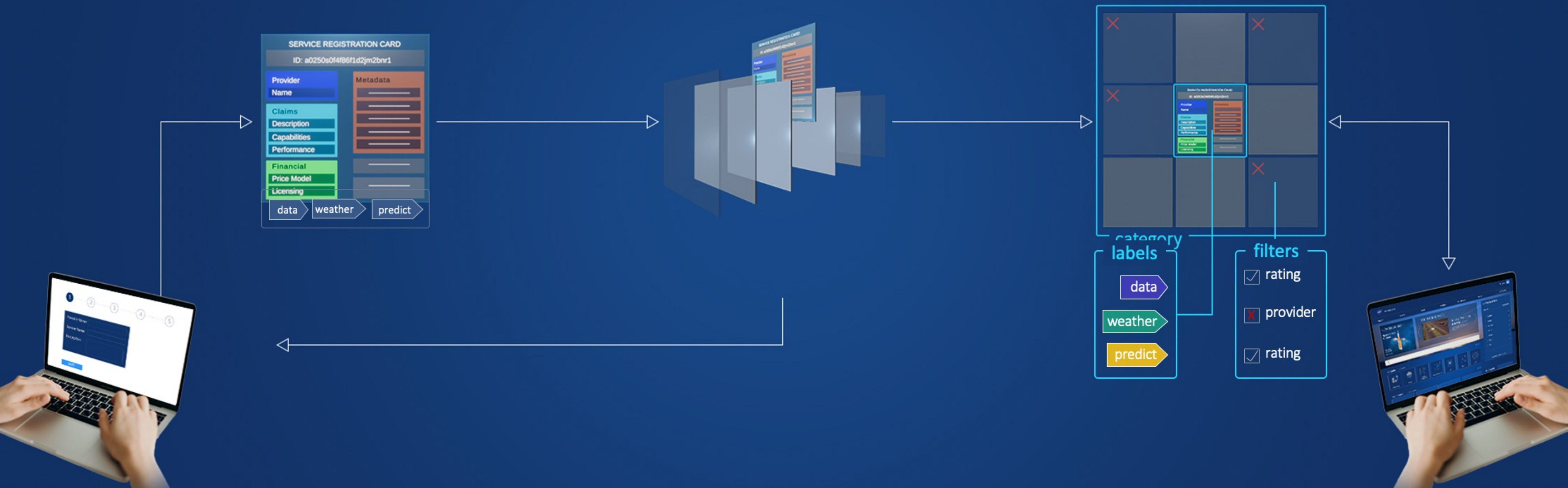
REGISTRATION

DISCOVERY

Enter service information
Into a registration form/document
(Automation under consideration)

Digital Information Platform
- **verifies document**
- **Persists information**
- **confirms registration**

Search or browse for a service
- **category/keyword/advanced search**
- **verifies document**
- **checks visibility**

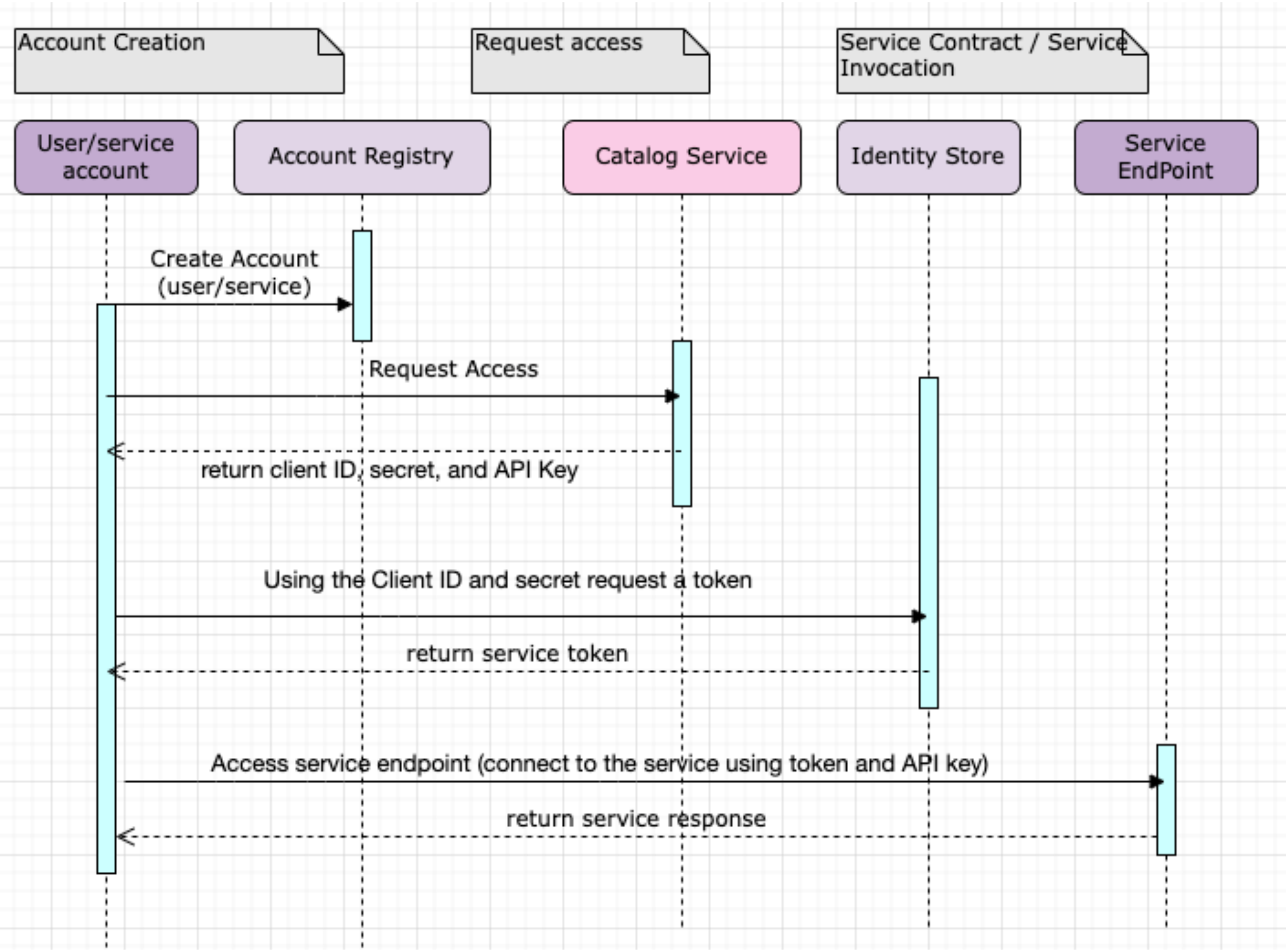


Service
PROVIDER

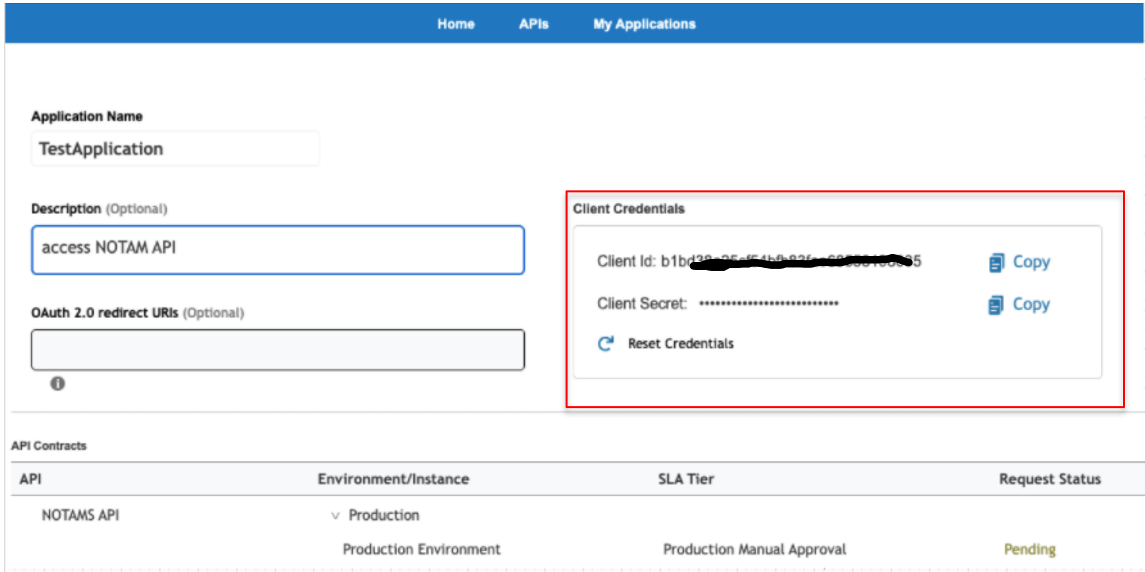
Catalog Service

Service
CONSUMER

Steps to Consume a Service from Platform



Account Creation
Request access
Service Contract / Service Invocation
User/service account
Account Registry
Catalog Service
Identity Store
Service EndPoint
Create Account (user/service)
Request Access
return client ID, secret, and API Key
Using the Client ID and secret request a token
return service token
Access service endpoint (connect to the service using token and API key)
return service response



Application Name
TestApplication

Description (Optional)
access NOTAM API

OAuth 2.0 redirect URIs (Optional)

Client Credentials

Client Id: b1bd[redacted]5 Copy

Client Secret: •••••••••••••••••••••••••• Copy

Reset Credentials

API Contracts

API	Environment/Instance	SLA Tier	Request Status
NOTAMS API	˅ Production		
	Production Environment	Production Manual Approval	Pending

•

Use Cases with Showcase Demo

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Eric Chevalley
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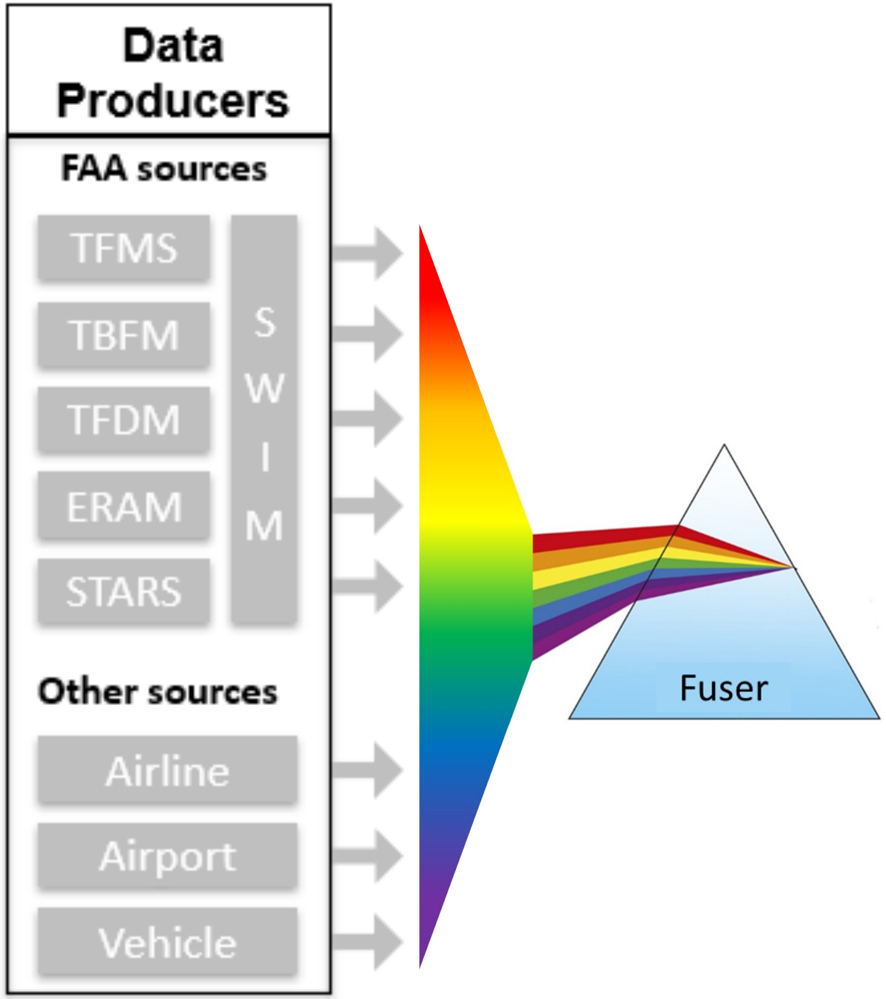
NASA Planned Services

- Data integration services
  - Integration of multiple sources into an added value service
    - Flight data integration (Fuser)
    - Traffic Management Initiative Service
- ML Prediction Services
  - Can be used to what-if different combinations of inputs
  - More inputs required
- Data Access APIs
  - Returns data produced by the NASA services infrastructure
  - Minimal inputs required
  - Inputs needed to produce a prediction were provided and orchestrated by the NASA service infrastructure

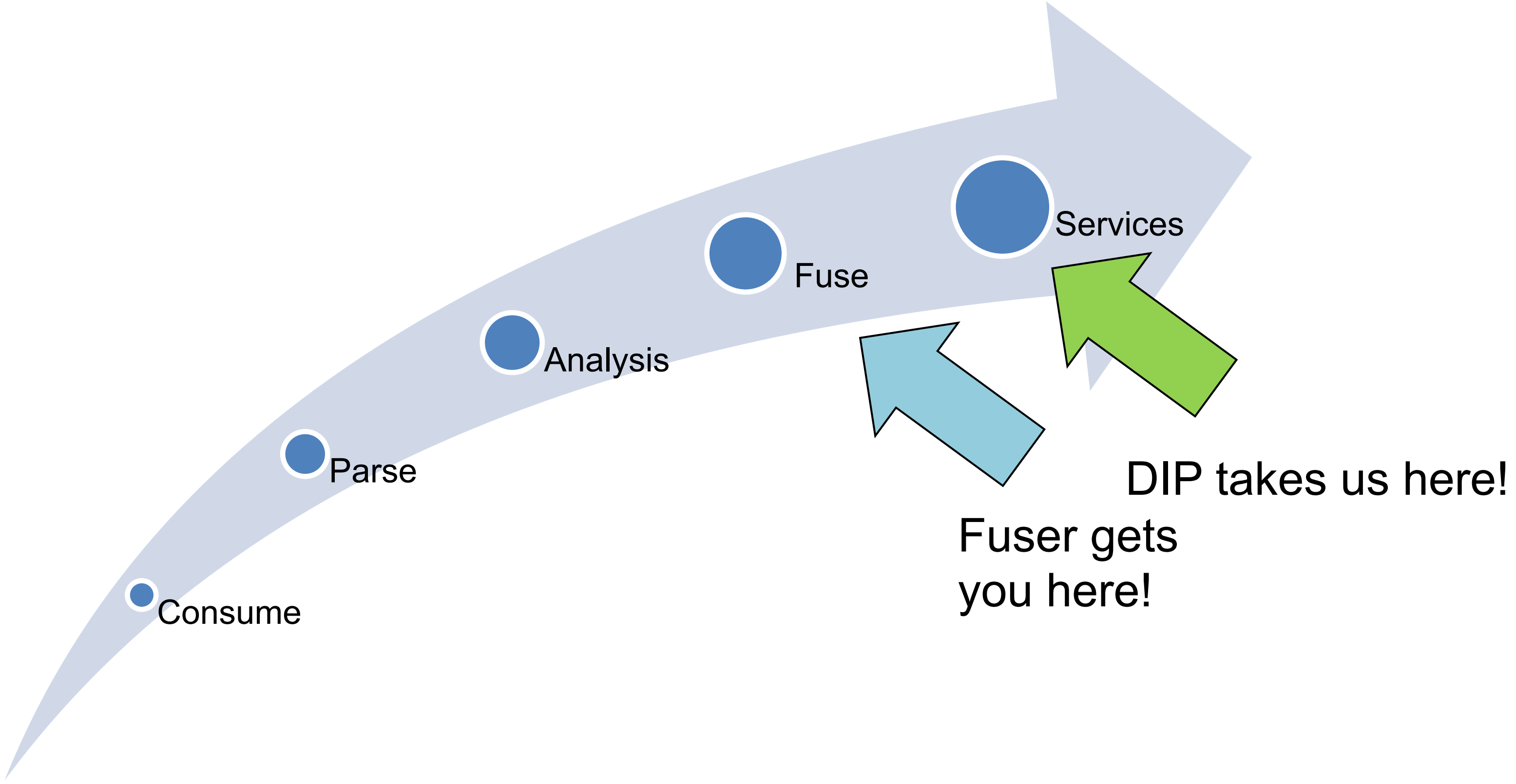
Data Integration Services - Fuser

- System that can mediate between disparate sources of data, pulling in the *right data, at the right time*
- Composed of multiple components providing
  - Parsers for various data sources
  - Matching Services providing a global unique identifier (GUFI)
  - Fusion Services
    - Transformation
    - Filtering
    - Updating
    - Mediation
  - Common well-defined schema



Beyond Fuser

- Fuser gets you closer to where you want to be faster
- Build data services on top and make them available



DIP takes us here!

Fuser gets
you here!

NASA ML Services Available on DIP Platform Summer 2022

1) **Runway configuration prediction:** predicts the set of active runways in 30-minute increments up to six hours into the future

2) **Runway prediction**: predicts the runway for departures/arrivals

3) **Unimpeded taxi time**: predicts unimpeded taxi time between gate and runway for departures and between runway and gate for arrivals

4) **Estimated ON time**: predicts the estimated landing time for arrivals

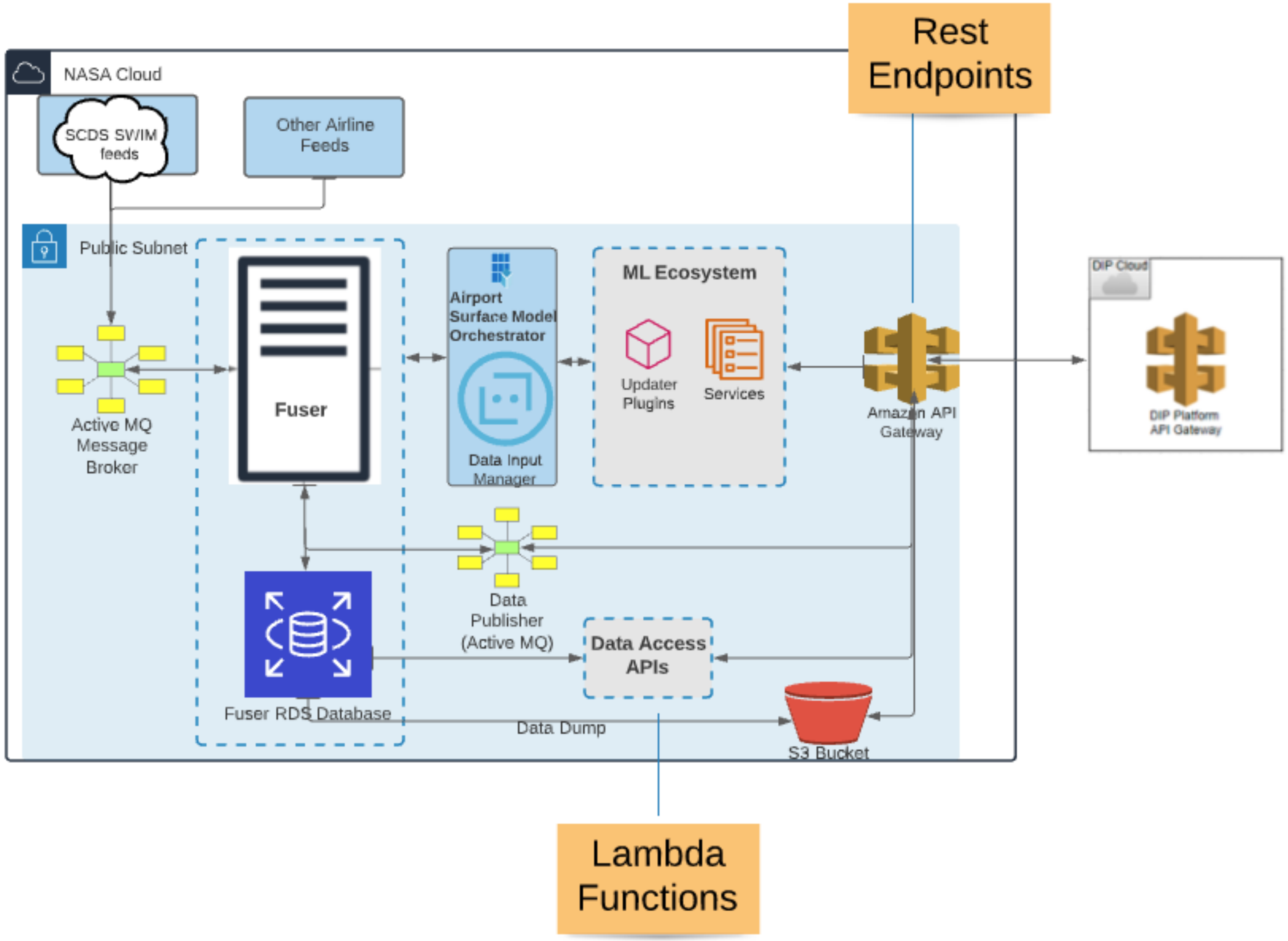
5) **Estimated Take Off Time**: predicts the take off time for departures incorporating all known constraints along terminal boundary and surface

NASA Data Access APIs Available on DIP Platform Summer 2022

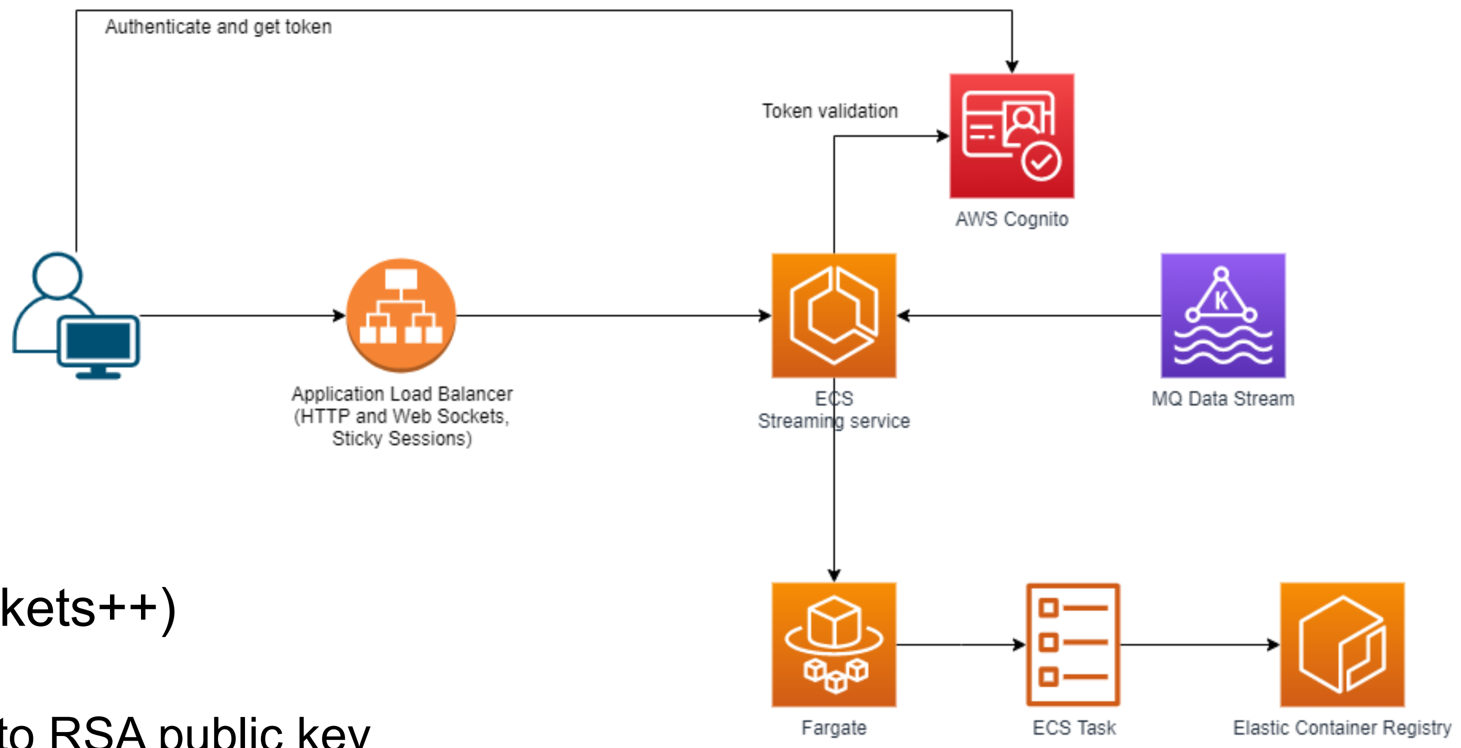
1) **Departure Runway -** Returns the coalesce of the actual (external source), detected (detection logic using position data), or modeled (predicted using machine learning model or decision tree service) departure runway value for a single flight.
2) **Arrival Runway -** Returns the coalesce of the actual (external source), detected (detection logic using position data), or modeled (predicted using machine learning model or decision tree service) arrival runway value for a single flight.
3) **Departure Runway Utilization -** Returns a collection of utilization values per departure runway that span a user defined time range and departure airport.
4) **Arrival Runway Utilization -** Returns a collection of utilization values per arrival runway that span a user defined time range and arrival airport.
5) **Departure Fix Utilization -** Returns a collection of utilization values per departure fix that span a user defined time range and departure airport.
6) **On Time -** Returns the coalesce of the actual (external source), detected (detection logic using position data), or modeled (predicted using machine learning model) arrival runway (ON) time for a flight or set of flights.
7) **Taxi In Impeded -** Returns the coalesce of the actual (detected) or modeled (predicted using machine learning model) impeded taxi in time for a flight or set of flights.
8) **Taxi In Unimpeded -** Returns the coalesce of the actual (detected) or modeled (predicted using machine learning model) unimpeded taxi in time for a flight or set of flights.
9) **Taxi Out Unimpeded -** Returns the coalesce of the actual (detected) or modeled (predicted using machine learning model) unimpeded taxi out time for a flight or set of flights.
10) **Flight Info –** Returns a collection of predictions and resources for a set of flights within a defined time window for a given airport

NASA Services Infrastructure

- A Fuser instance processes data from the FAA SWIM Cloud Distribution Service (SCDS), along with other airline data feeds
- A NAS Model Orchestrator manages formulating inputs for reusable ML microservices in the ML Ecosystem
- All orchestrated data flows back to the Fuser
- Fuser data captured in databases, S3, and streamed
- ML services available via API calls
- Data Access APIs provide access to:
  - Fused data
  - ML model output orchestrated by the Airport Surface Model
  - Counts and metrics



Fuser Streaming Architecture


Authenticate and get token
Token validation
AWS Cognito
Application Load Balancer (HTTP and Web Sockets, Sticky Sessions)
ECS Streaming service
MQ Data Stream
Fargate
ECS Task
Elastic Container Registry

- Node.js Service running in ECS
- Utilizes socket.ui library (websockets++)
- Cognito Authentication (JWT)
  - Signature validation with Cognito RSA public key
  - Custom Scope validation
- Endpoints Exposed by Application Load Balancer
- Consumes from AWS MQ, broadcasts over socket to all connected clients

Service Consumption Demos

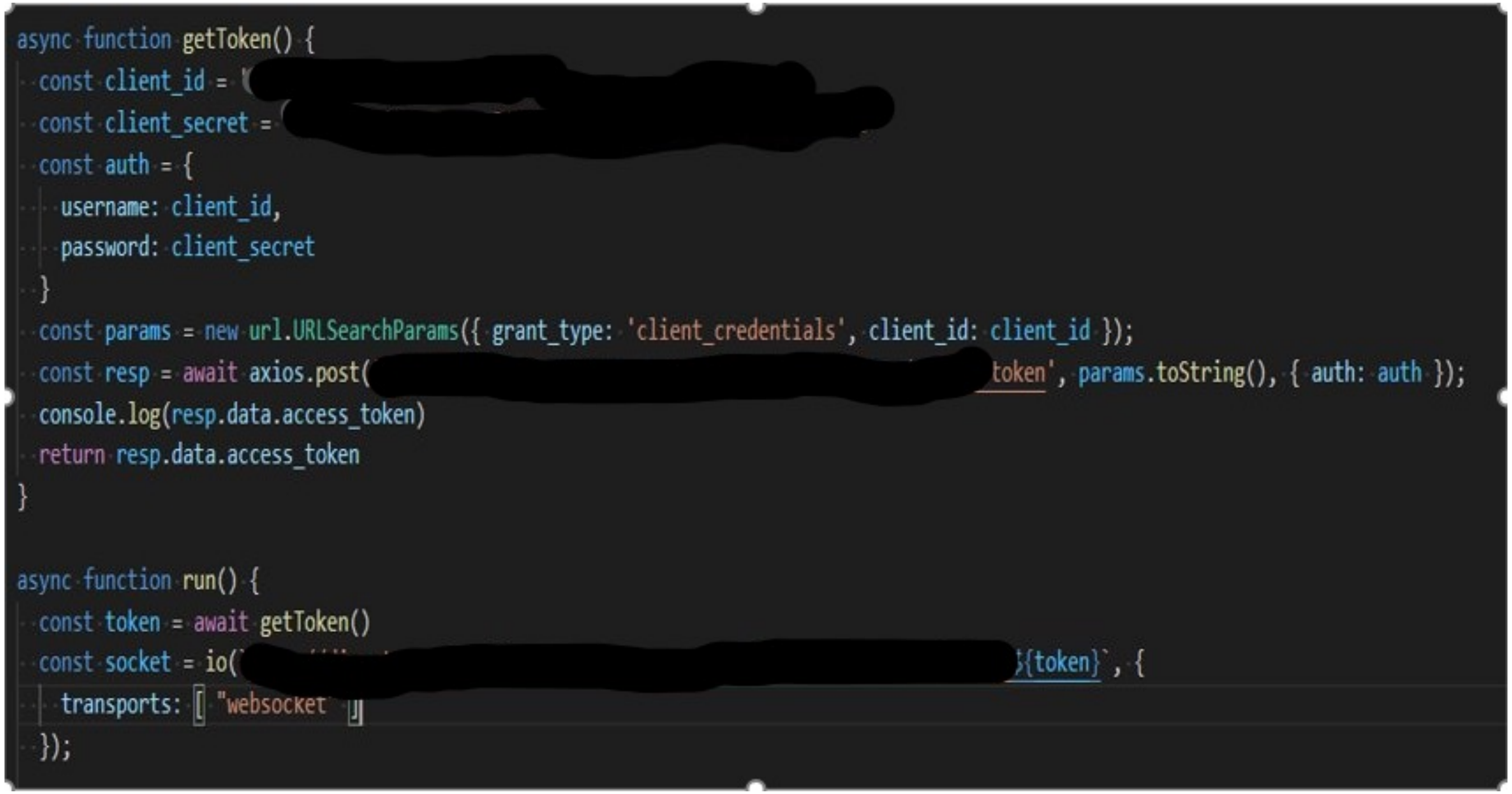
- Consuming Fuser stream via Socket.IO
- NASA Departure Runway Service using Postman
- NASA Runway Utilization Service using Python and Plotly/Dash
- NASA Flight Info using JavaScript

* Only the data is being made available via the DIP platform

** Visualization capabilities shown in the demo are not part of the DIP platform

Consuming the Fuser stream Client

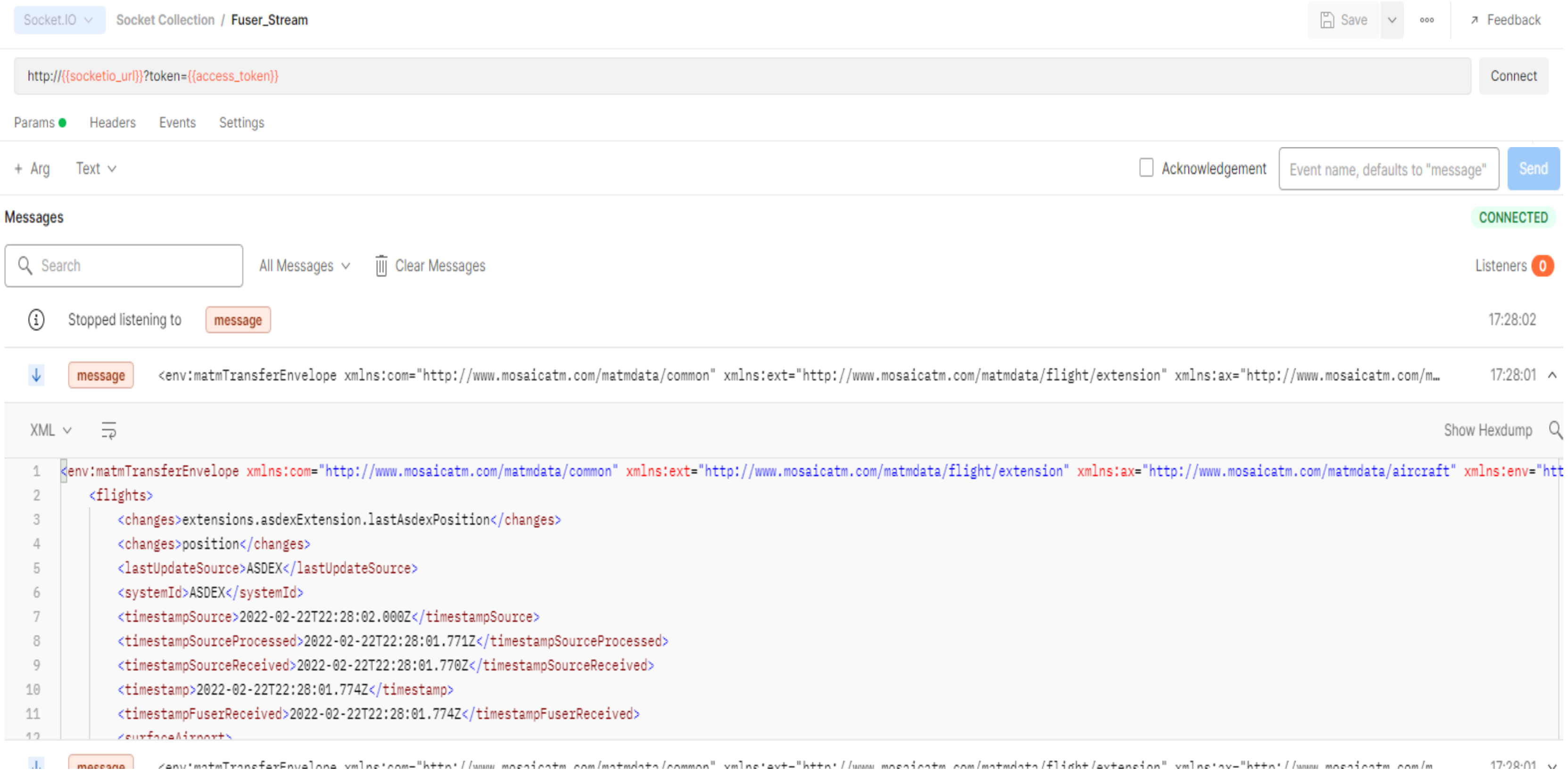
- Use any socket.io client library
- Get a token from Cognito
- Connect
- Listen for messages
- Connection stays open until client closes it



```
async function getToken() {
  const client_id = '[redacted]
  const client_secret =
  const auth = {
    username: client_id,
    password: client_secret
  }
  const params = new url.URLSearchParams({ grant_type: 'client_credentials', client_id: client_id });
  const resp = await axios.post([redacted]token', params.toString(), { auth: auth });
  console.log(resp.data.access_token)
  return resp.data.access_token
}

async function run() {
  const token = await getToken()
  const socket = io(`[redacted]${token}`, {
    transports: [ "websocket ]
  });
```

Consuming Fuser Stream Using Postman

- Postman client for testing
- Socket.io client libraries available in most languages



http://{{socketio_url}}?token={{access_token}}

Stopped listening to message 17:28:02

message <env:matmTransferEnvelope xmlns:com="http://www.mosaicatm.com/matmdata/common" xmlns:ext="http://www.mosaicatm.com/matmdata/flight/extension" xmlns:ax="http://www.mosaicatm.com/m… 17:28:01

```
<env:matmTransferEnvelope xmlns:com="http://www.mosaicatm.com/matmdata/common" xmlns:ext="http://www.mosaicatm.com/matmdata/flight/extension" xmlns:ax="http://www.mosaicatm.com/matmdata/aircraft" xmlns:env="htt
  <flights>
    <changes>extensions.asdexExtension.lastAsdexPosition</changes>
    <changes>position</changes>
    <lastUpdateSource>ASDEX</lastUpdateSource>
    <systemId>ASDEX</systemId>
    <timestampSource>2022-02-22T22:28:02.000Z</timestampSource>
    <timestampSourceProcessed>2022-02-22T22:28:01.771Z</timestampSourceProcessed>
    <timestampSourceReceived>2022-02-22T22:28:01.770Z</timestampSourceReceived>
    <timestamp>2022-02-22T22:28:01.774Z</timestamp>
    <timestampFuserReceived>2022-02-22T22:28:01.774Z</timestampFuserReceived>
    <surfaceAirport>
```

message <env:matmTransferEnvelope xmlns:com="http://www.mosaicatm.com/matmdata/common" xmlns:ext="http://www.mosaicatm.com/matmdata/flight/extension" xmlns:ax="http://www.mosaicatm.com/m 17:28:01

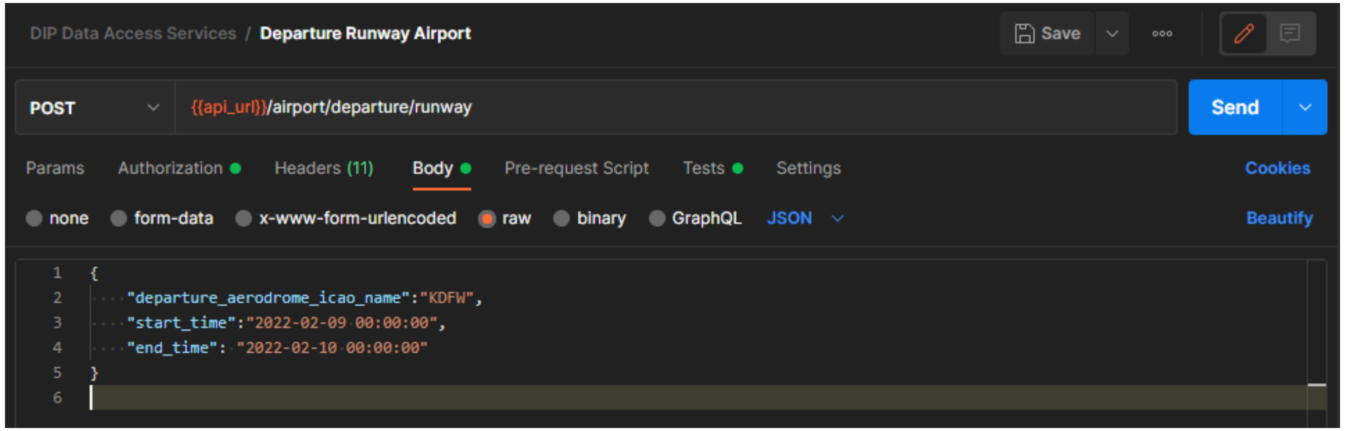
Departure Runway Service Demo using Postman

- NASA Departure Runway Service - The Departure Runway Service returns the coalesce of the actual (external source), detected (detection logic using position data), or modeled (predicted using machine learning model or decision tree service) departure runway for a flight or flights.

- Postman
  - Opensource utility for evaluating API requests
    - Graphical interface for accessing REST endpoints
    - Automatically formats text responses
    - Built-in HTML Visualizer
    - https://www.postman.com/
  - Codeless approach for testing API requests

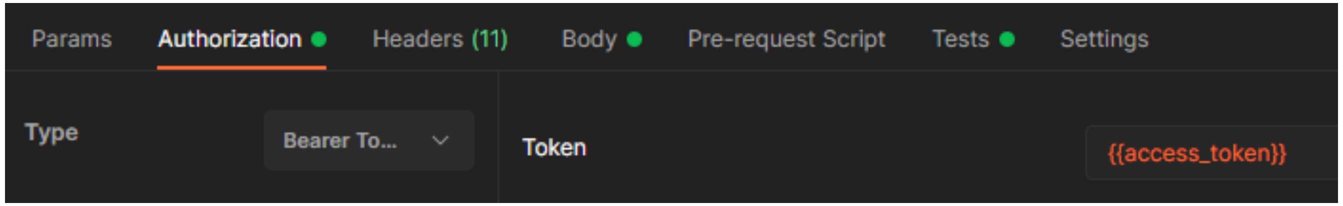
Postman – Making a Request

- Request Cognito Token
  - Request requires known client id and secret
- Create API CRUD Request
  - Provide the message body
  - Provide the token
  - Provide the content type and API key



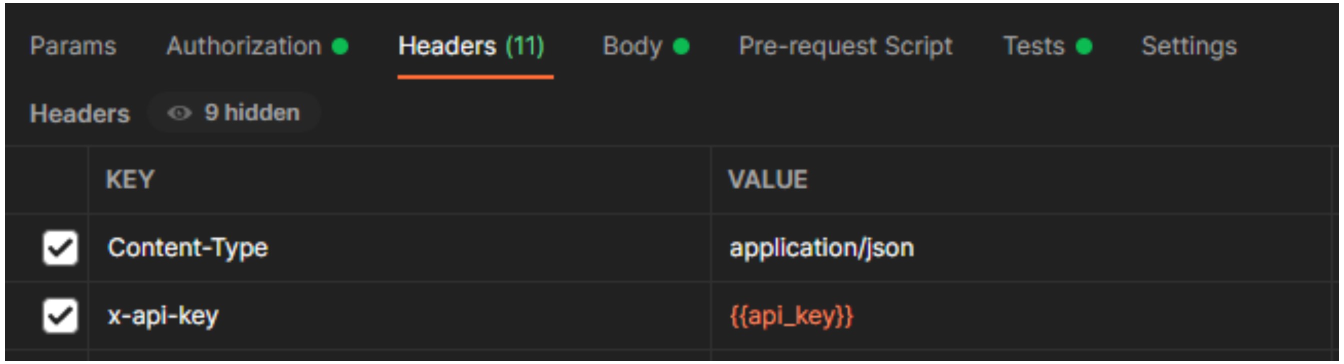
POST {{api_url}}/airport/departure/runway

```
{
    "departure_aerodrome_icao_name":"KDFW",
    "start_time":"2022-02-09 00:00:00",
    "end_time": "2022-02-10 00:00:00"
}
```



Type Bearer To...

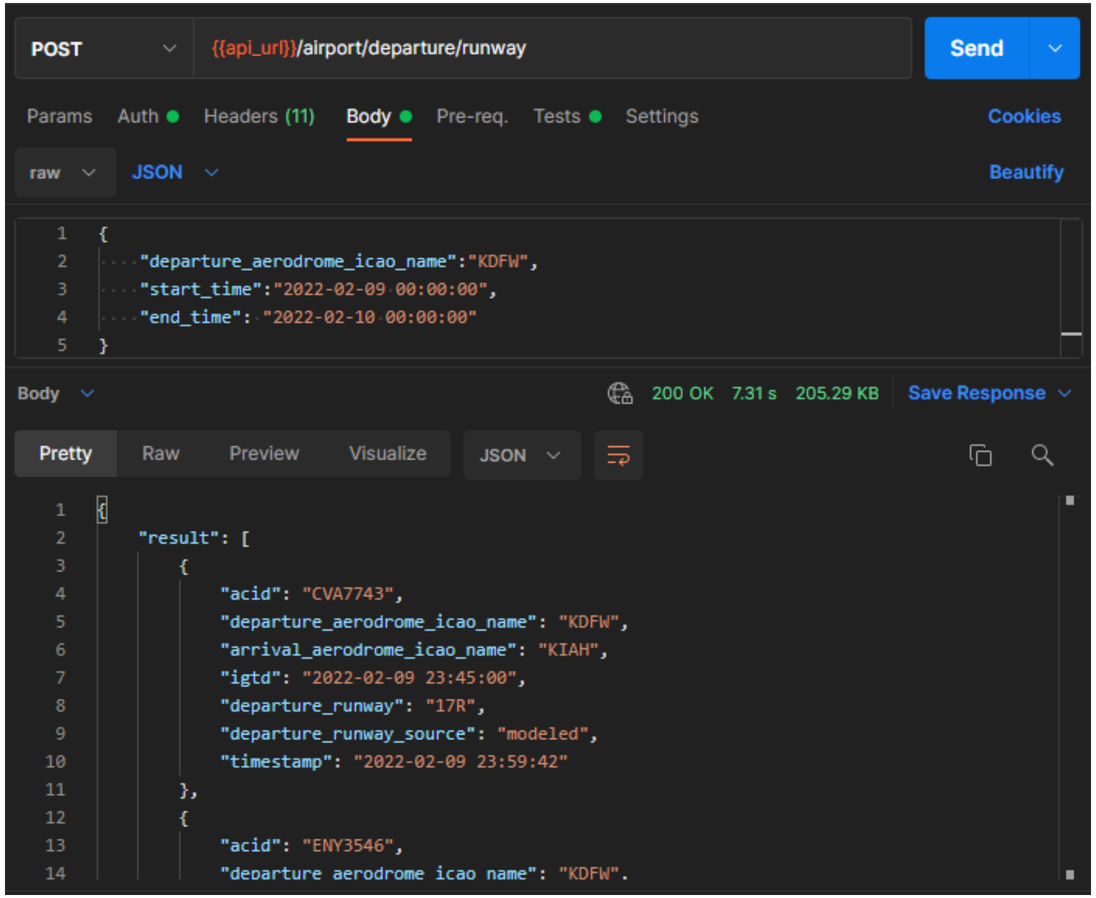
Token {{access_token}}



	KEY	VALUE
☑	Content-Type	application/json
☑	x-api-key	{{api_key}}

Postman - Visualization

- Results display in pretty-printed plain text



POST {{api_url}}/airport/departure/runway

```
{
    "departure_aerodrome_icao_name":"KDFW",
    "start_time":"2022-02-09 00:00:00",
    "end_time": "2022-02-10 00:00:00"
}
```

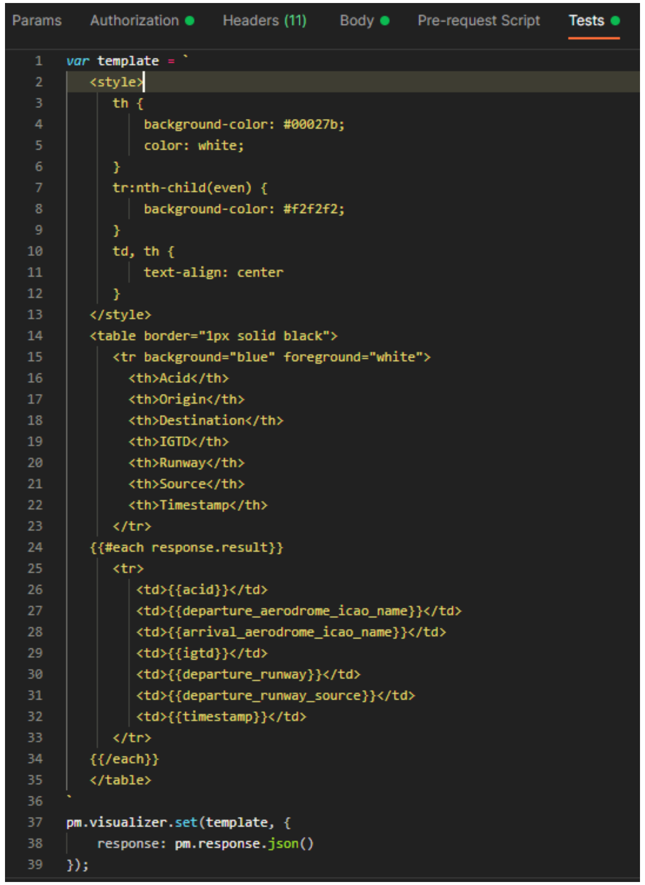
Body   200 OK   7.31 s   205.29 KB

Pretty   JSON

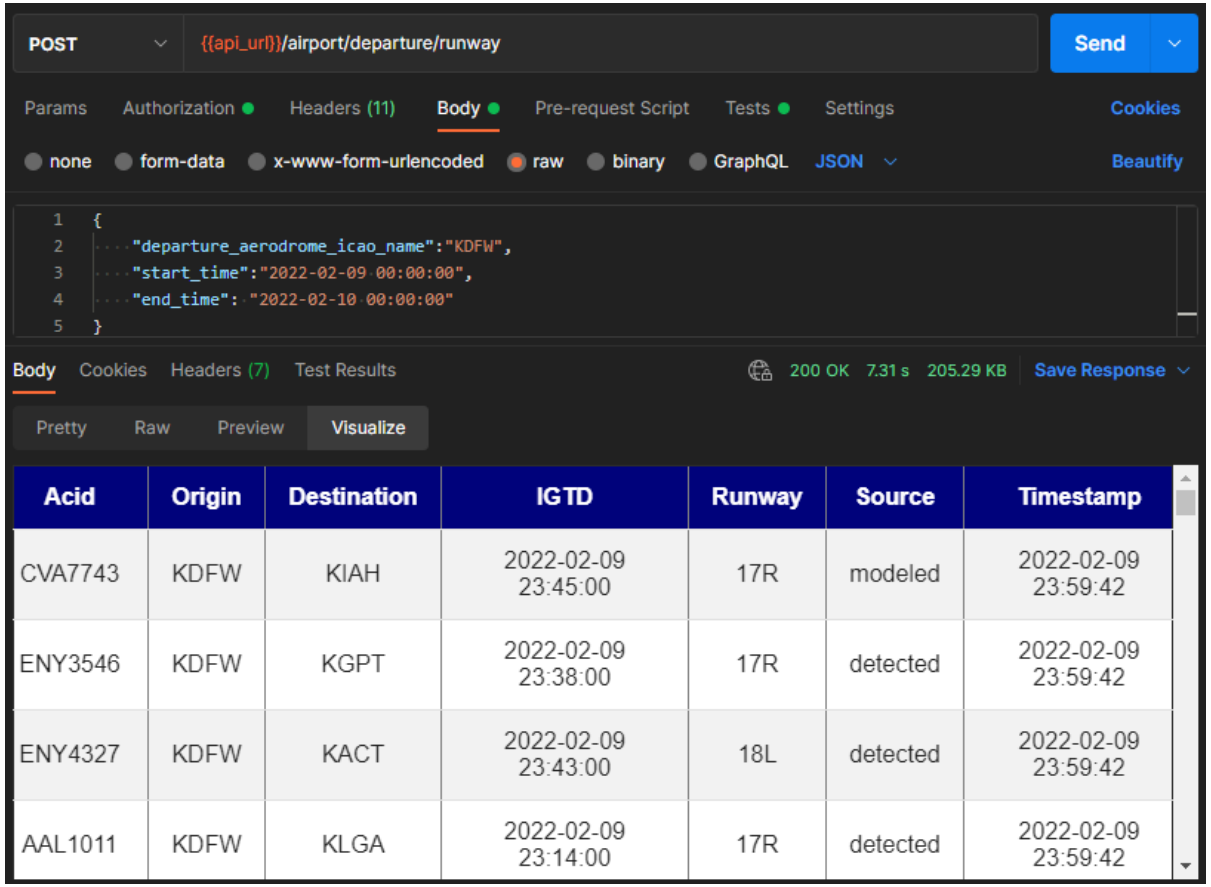
```
{
    "result": [
        {
            "acid": "CVA7743",
            "departure_aerodrome_icao_name": "KDFW",
            "arrival_aerodrome_icao_name": "KIAH",
            "igtd": "2022-02-09 23:45:00",
            "departure_runway": "17R",
            "departure_runway_source": "modeled",
            "timestamp": "2022-02-09 23:59:42"
        },
        {
            "acid": "ENY3546",
            "departure_aerodrome_icao_name": "KDFW",
```

Departure Runway Custom Visualization Using Postman

- Results display using custom visualization code
- Postman provides templating which support HTML and JavaScript



```
var template = `
   <style>
      th {
          background-color: #00027b;
          color: white;
      }
      tr:nth-child(even) {
          background-color: #f2f2f2;
      }
      td, th {
          text-align: center
      }
   </style>
   <table border="1px solid black">
      <tr background="blue" foreground="white">
        <th>Acid</th>
        <th>Origin</th>
        <th>Destination</th>
        <th>IGTD</th>
        <th>Runway</th>
        <th>Source</th>
        <th>Timestamp</th>
      </tr>
   {{#each response.result}}
      <tr>
         <td>{{acid}}</td>
         <td>{{departure_aerodrome_icao_name}}</td>
         <td>{{arrival_aerodrome_icao_name}}</td>
         <td>{{igtd}}</td>
         <td>{{departure_runway}}</td>
         <td>{{departure_runway_source}}</td>
         <td>{{timestamp}}</td>
      </tr>
   {{/each}}
   </table>
`

pm.visualizer.set(template, {
    response: pm.response.json()
});
```



POST {{api_url}}/airport/departure/runway

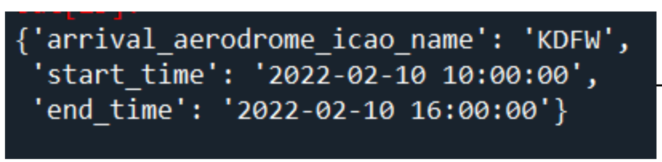
```
{
    "departure_aerodrome_icao_name":"KDFW",
    "start_time":"2022-02-09 00:00:00",
    "end_time": "2022-02-10 00:00:00"
}
```

200 OK 7.31 s 205.29 KB

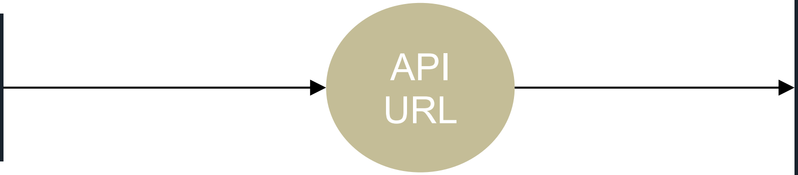
Acid	Origin	Destination	IGTD	Runway	Source	Timestamp
CVA7743	KDFW	KIAH	2022-02-09 23:45:00	17R	modeled	2022-02-09 23:59:42
ENY3546	KDFW	KGPT	2022-02-09 23:38:00	17R	detected	2022-02-09 23:59:42
ENY4327	KDFW	KACT	2022-02-09 23:43:00	18L	detected	2022-02-09 23:59:42
AAL1011	KDFW	KLGA	2022-02-09 23:14:00	17R	detected	2022-02-09 23:59:42

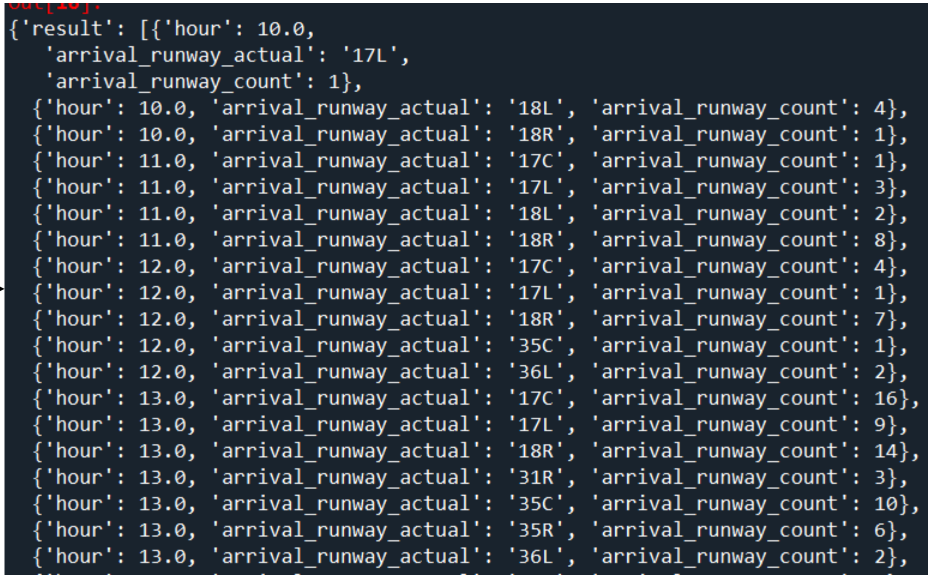
Arrival Runway Utilization using Python

- Using *requests* module in Python to obtain data:
  - Obtain access token
  - Post request to API URL
  - Data returned in *json* format



```
{'arrival_aerodrome_icao_name': 'KDFW',
 'start_time': '2022-02-10 10:00:00',
 'end_time': '2022-02-10 16:00:00'}
```

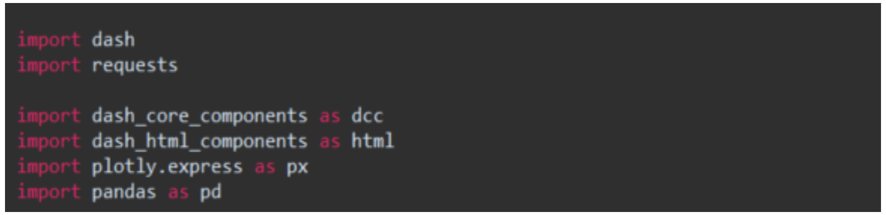




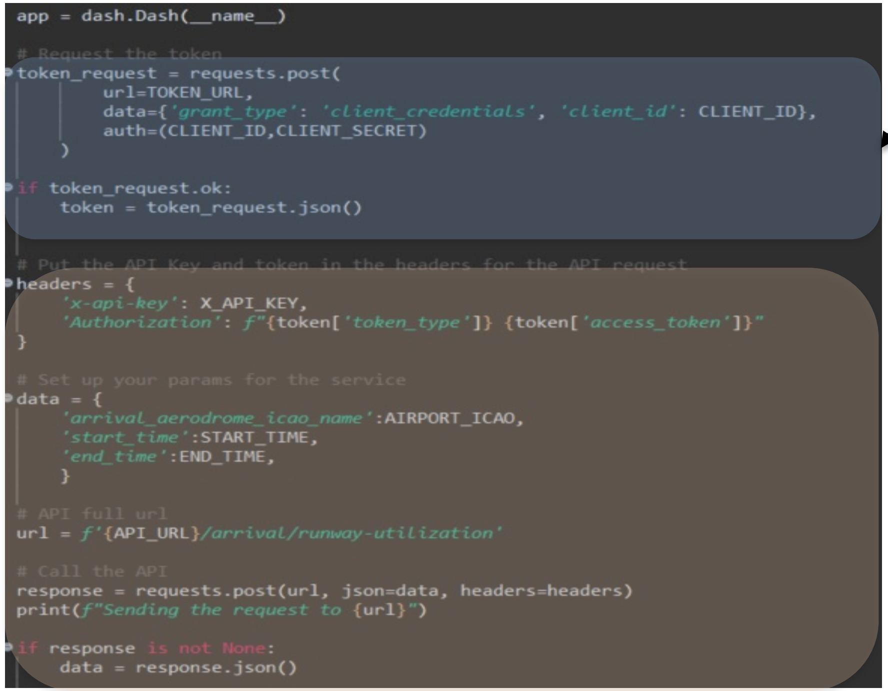
```
{'result': [{'hour': 10.0,
   'arrival_runway_actual': '17L',
   'arrival_runway_count': 1},
  {'hour': 10.0, 'arrival_runway_actual': '18L', 'arrival_runway_count': 4},
  {'hour': 10.0, 'arrival_runway_actual': '18R', 'arrival_runway_count': 1},
  {'hour': 11.0, 'arrival_runway_actual': '17C', 'arrival_runway_count': 1},
  {'hour': 11.0, 'arrival_runway_actual': '17L', 'arrival_runway_count': 3},
  {'hour': 11.0, 'arrival_runway_actual': '18L', 'arrival_runway_count': 2},
  {'hour': 11.0, 'arrival_runway_actual': '18R', 'arrival_runway_count': 8},
  {'hour': 12.0, 'arrival_runway_actual': '17C', 'arrival_runway_count': 4},
  {'hour': 12.0, 'arrival_runway_actual': '17L', 'arrival_runway_count': 1},
  {'hour': 12.0, 'arrival_runway_actual': '18R', 'arrival_runway_count': 7},
  {'hour': 12.0, 'arrival_runway_actual': '35C', 'arrival_runway_count': 1},
  {'hour': 12.0, 'arrival_runway_actual': '36L', 'arrival_runway_count': 2},
  {'hour': 13.0, 'arrival_runway_actual': '17C', 'arrival_runway_count': 16},
  {'hour': 13.0, 'arrival_runway_actual': '17L', 'arrival_runway_count': 9},
  {'hour': 13.0, 'arrival_runway_actual': '18R', 'arrival_runway_count': 14},
  {'hour': 13.0, 'arrival_runway_actual': '31R', 'arrival_runway_count': 3},
  {'hour': 13.0, 'arrival_runway_actual': '35C', 'arrival_runway_count': 10},
  {'hour': 13.0, 'arrival_runway_actual': '35R', 'arrival_runway_count': 6},
  {'hour': 13.0, 'arrival_runway_actual': '36L', 'arrival_runway_count': 2},
```

- Using *Plotly/Dash* modules for visualization

Arrival Runway Utilization Chart



```
import dash
import requests

import dash_core_components as dcc
import dash_html_components as html
import plotly.express as px
import pandas as pd
```

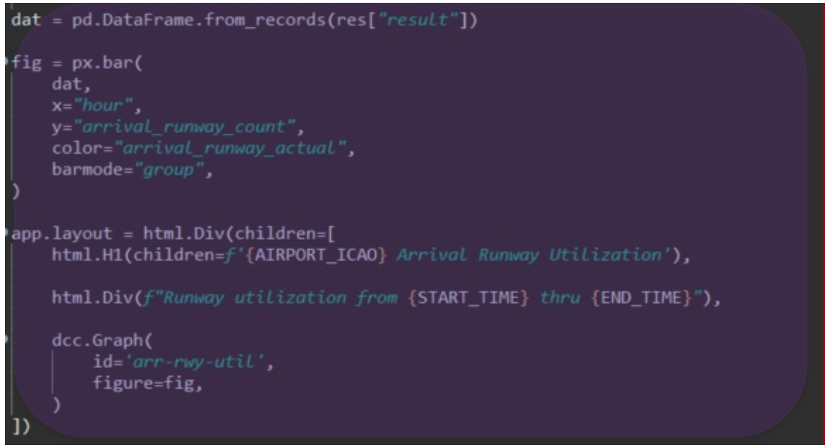


```
app = dash.Dash(__name__)

# Request the token
token_request = requests.post(
        url=TOKEN_URL,
        data={'grant_type': 'client_credentials', 'client_id': CLIENT_ID},
        auth=(CLIENT_ID,CLIENT_SECRET)
    )

if token_request.ok:
    token = token_request.json()

# Put the API Key and token in the headers for the API request
headers = {
    'x-api-key': X_API_KEY,
    'Authorization': f"{token['token_type']} {token['access_token']}"
}

# Set up your params for the service
data = {
    'arrival_aerodrome_icao_name':AIRPORT_ICAO,
    'start_time':START_TIME,
    'end_time':END_TIME,
    }

# API full url
url = f'{API_URL}/arrival/runway-utilization'

# Call the API
response = requests.post(url, json=data, headers=headers)
print(f"Sending the request to {url}")

if response is not None:
    data = response.json()
```

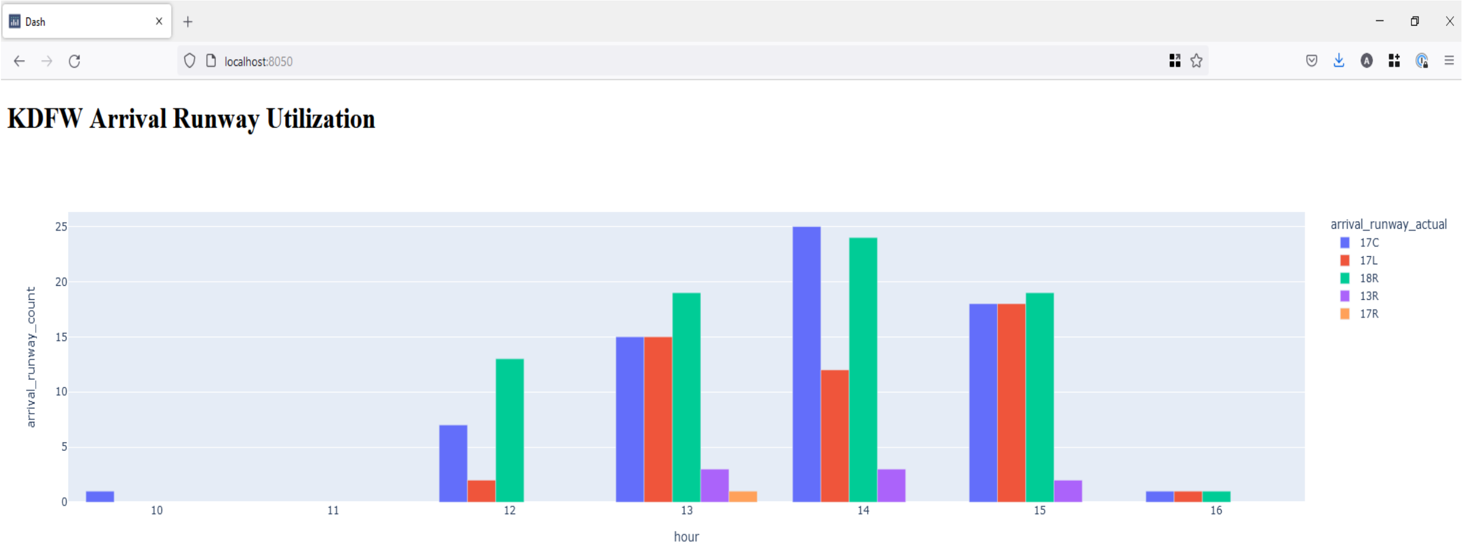
Get Access Token

Data requests from API

Bar chart generation



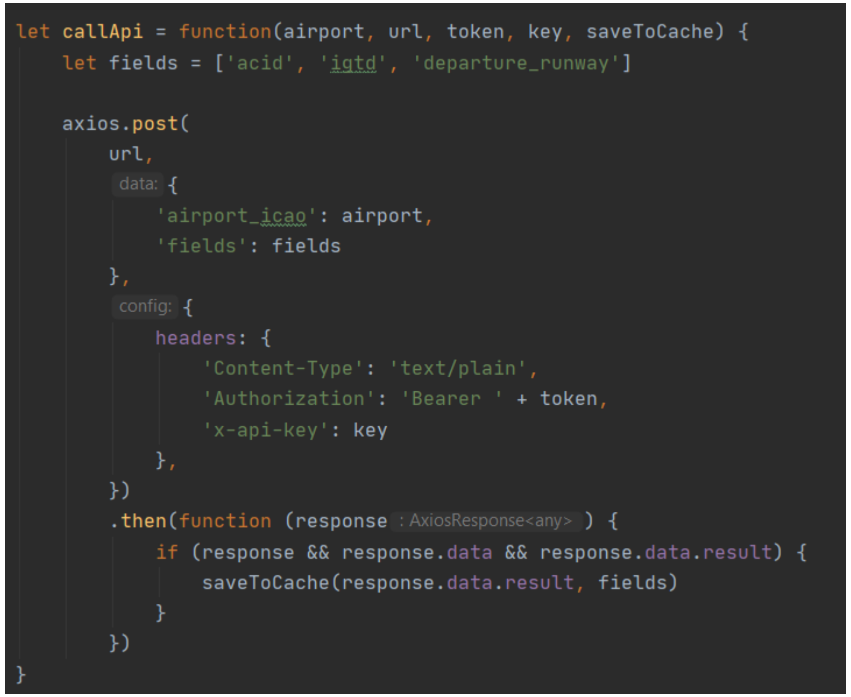
```
dat = pd.DataFrame.from_records(res["result"])

fig = px.bar(
    dat,
    x="hour",
    y="arrival_runway_count",
    color="arrival_runway_actual",
    barmode="group",
)

app.layout = html.Div(children=[
    html.H1(children=f'{AIRPORT_ICAO} Arrival Runway Utilization'),

    html.Div(f"Runway utilization from {START_TIME} thru {END_TIME}"),

    dcc.Graph(
        id='arr-rwy-util',
        figure=fig,
    )
])
```



KDFW Arrival Runway Utilization

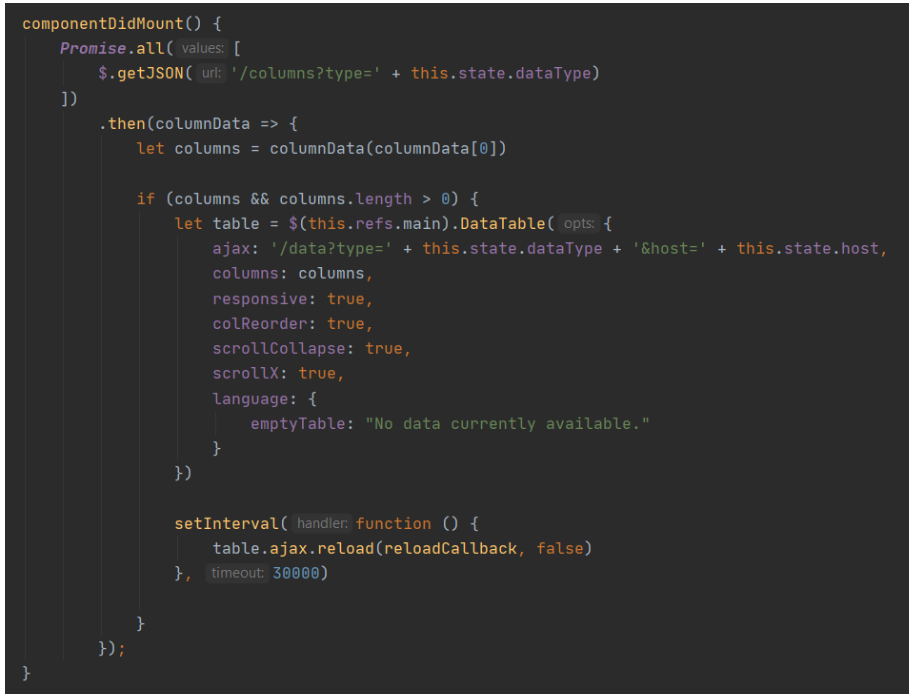
NASA Flight Info Service using JavaScript

- Visualization of NASA Flight Info Service data in web client table
  - Including search, sorting, and filtering capabilities
- Built using Node.js, paired with React and DataTables for front end



```
let callApi = function(airport, url, token, key, saveToCache) {
    let fields = ['acid', 'igtd', 'departure_runway']

    axios.post(
        url,
        data: {
            'airport_icao': airport,
            'fields': fields
        },
        config: {
            headers: {
                'Content-Type': 'text/plain',
                'Authorization': 'Bearer ' + token,
                'x-api-key': key
            },
        })
        .then(function (response : AxiosResponse<any> ) {
            if (response && response.data && response.data.result) {
                saveToCache(response.data.result, fields)
            }
        })
}
```

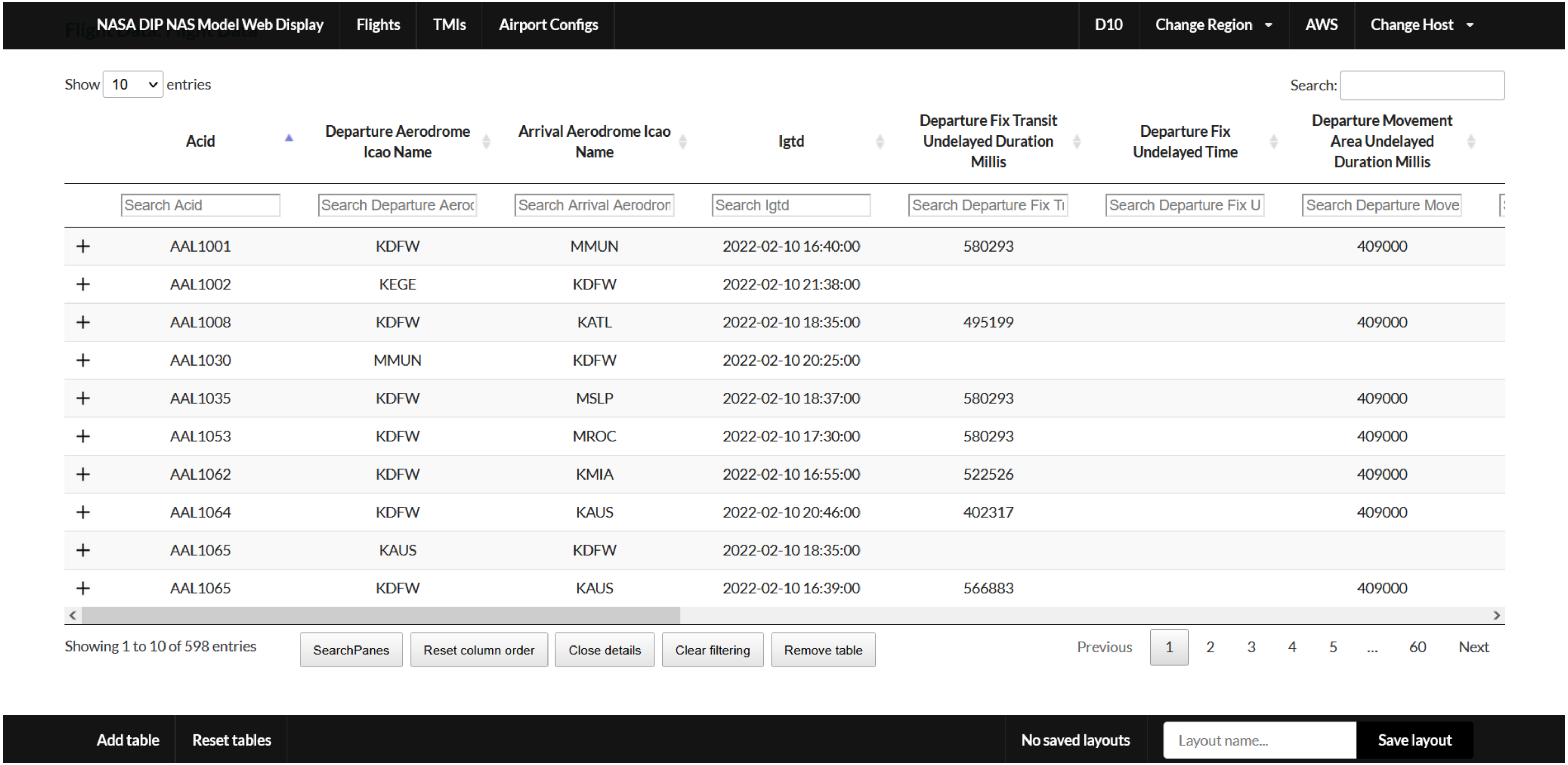
API call using Axios to retrieve and save DIP Service Data



```
componentDidMount() {
    Promise.all( values: [
        $.getJSON( url: '/columns?type=' + this.state.dataType)
    ])
        .then(columnData => {
            let columns = columnData(columnData[0])

            if (columns && columns.length > 0) {
                let table = $(this.refs.main).DataTable( opts: {
                    ajax: '/data?type=' + this.state.dataType + '&host=' + this.state.host,
                    columns: columns,
                    responsive: true,
                    colReorder: true,
                    scrollCollapse: true,
                    scrollX: true,
                    language: {
                        emptyTable: "No data currently available."
                    }
                })

                setInterval( handler: function () {
                    table.ajax.reload(reloadCallback, false)
                }, timeout: 30000)

            }
        });
}
```

React method to create DataTable using cached data and columns (same values as ‘fields’ in API call)

Flight Info Service Demo Web Client



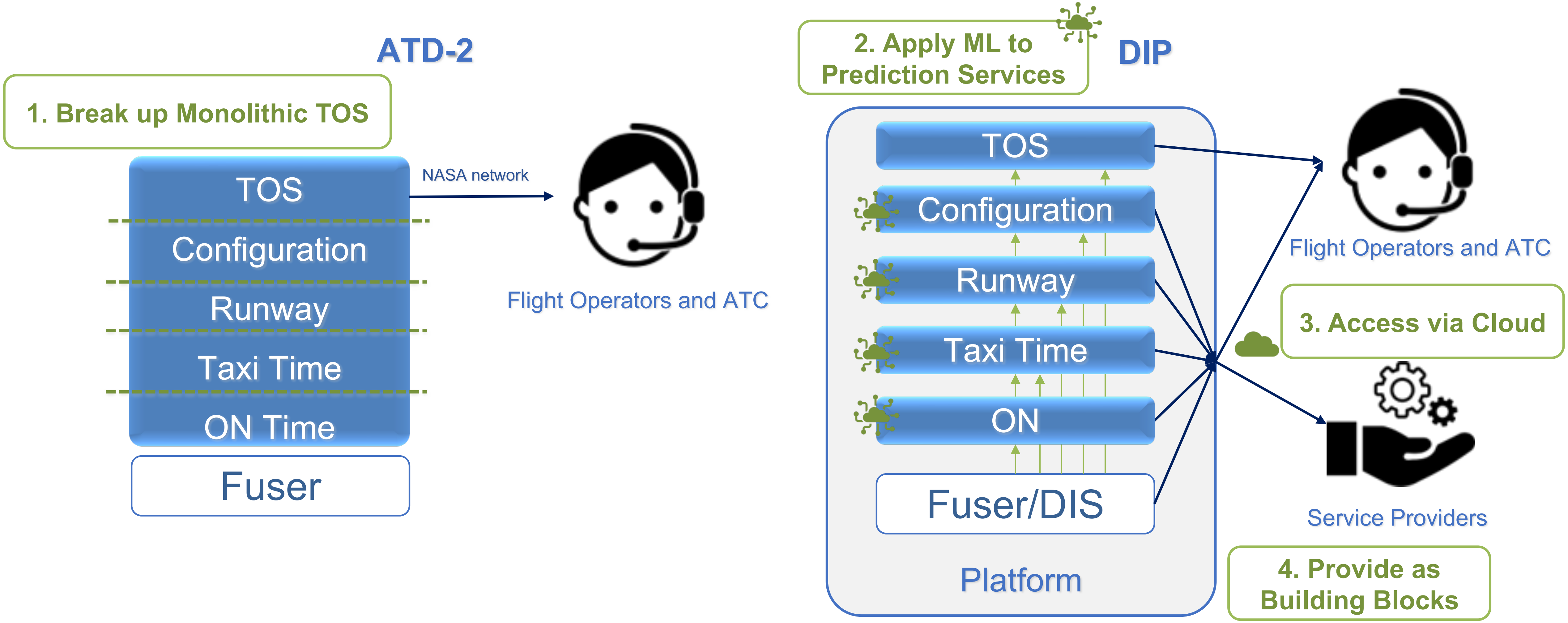
Show 10 entries

	Acid	Departure Aerodrome Icao Name	Arrival Aerodrome Icao Name	Igtd	Departure Fix Transit Undelayed Duration Millis	Departure Fix Undelayed Time	Departure Movement Area Undelayed Duration Millis
+	AAL1001	KDFW	MMUN	2022-02-10 16:40:00	580293		409000
+	AAL1002	KEGE	KDFW	2022-02-10 21:38:00			
+	AAL1008	KDFW	KATL	2022-02-10 18:35:00	495199		409000
+	AAL1030	MMUN	KDFW	2022-02-10 20:25:00			
+	AAL1035	KDFW	MSLP	2022-02-10 18:37:00	580293		409000
+	AAL1053	KDFW	MROC	2022-02-10 17:30:00	580293		409000
+	AAL1062	KDFW	KMIA	2022-02-10 16:55:00	522526		409000
+	AAL1064	KDFW	KAUS	2022-02-10 20:46:00	402317		409000
+	AAL1065	KAUS	KDFW	2022-02-10 18:35:00			
+	AAL1065	KDFW	KAUS	2022-02-10 16:39:00	566883		409000

Showing 1 to 10 of 598 entries

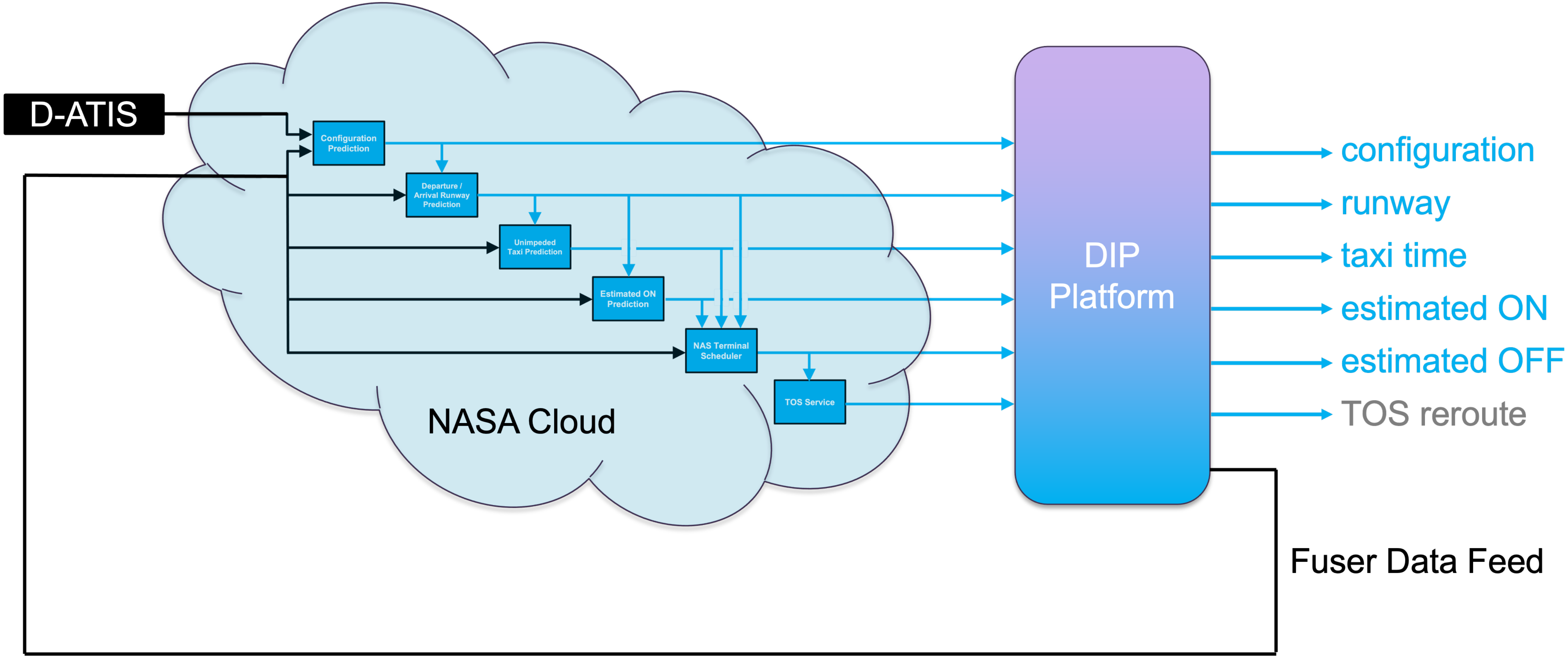
NASA Developed Machine Learning Services

Using NASA Services as Building Blocks



"DIP-itize" – Scalability towards NAS-wide implementation

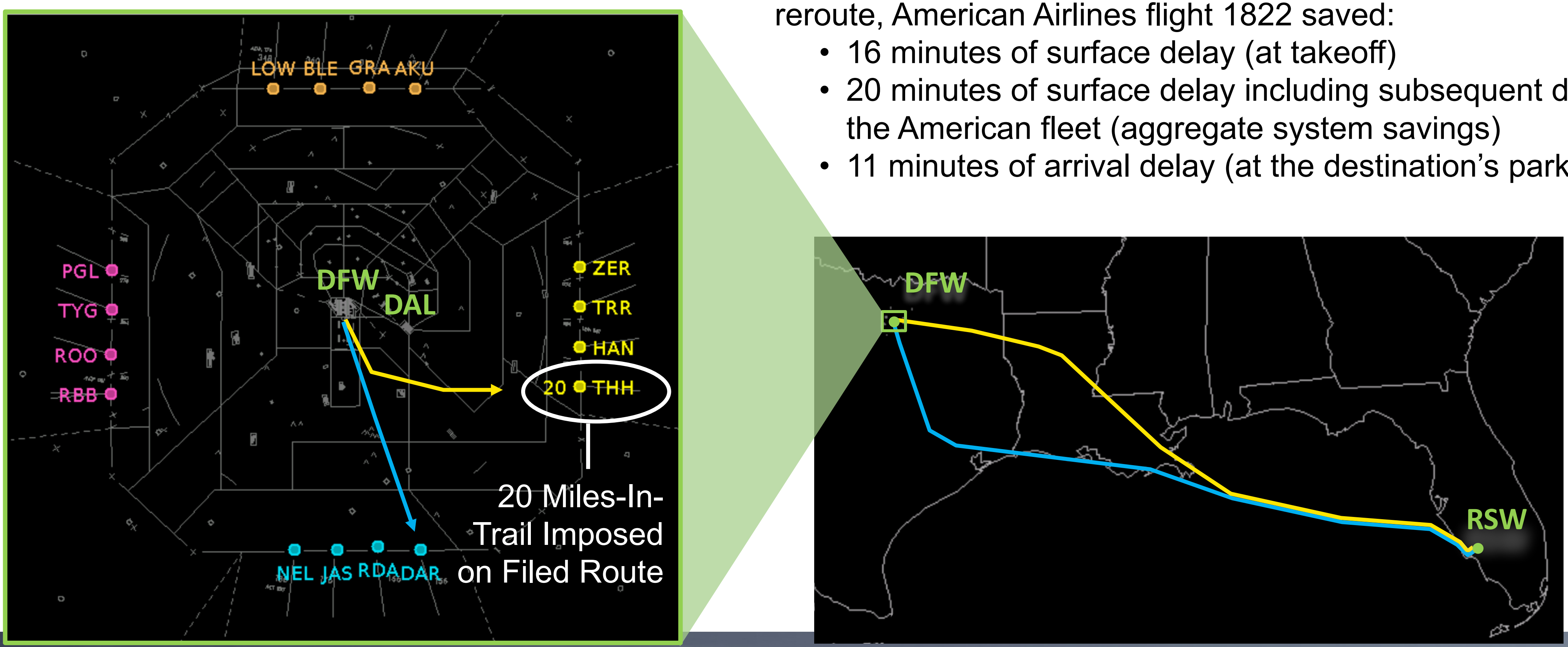
NASA Developed Machine Learning Services



Collaborative Digital Departure Reroute (CDDR)

On March 26, 2021, American Airlines 1822 flew Dallas/Fort-Worth (DFW) to Fort Myers (RSW) on a reroute recommended by NASA

- American Airlines 1822 was initially filed on the **yellow route**
- ATD-2 projected surface delay due to constraints on the East departure gate
- Based on American TOS preferences, ATD-2 recommended the **blue reroute** out the south gate
- Even though the blue route was 42nm longer, by flying this TOS alternate reroute, American Airlines flight 1822 saved:
  - 16 minutes of surface delay (at takeoff)
  - 20 minutes of surface delay including subsequent departure flights in the American fleet (aggregate system savings)
  - 11 minutes of arrival delay (at the destination's parking gate)



20 Miles-In-Trail Imposed on Filed Route

Ways to Access NASA Services

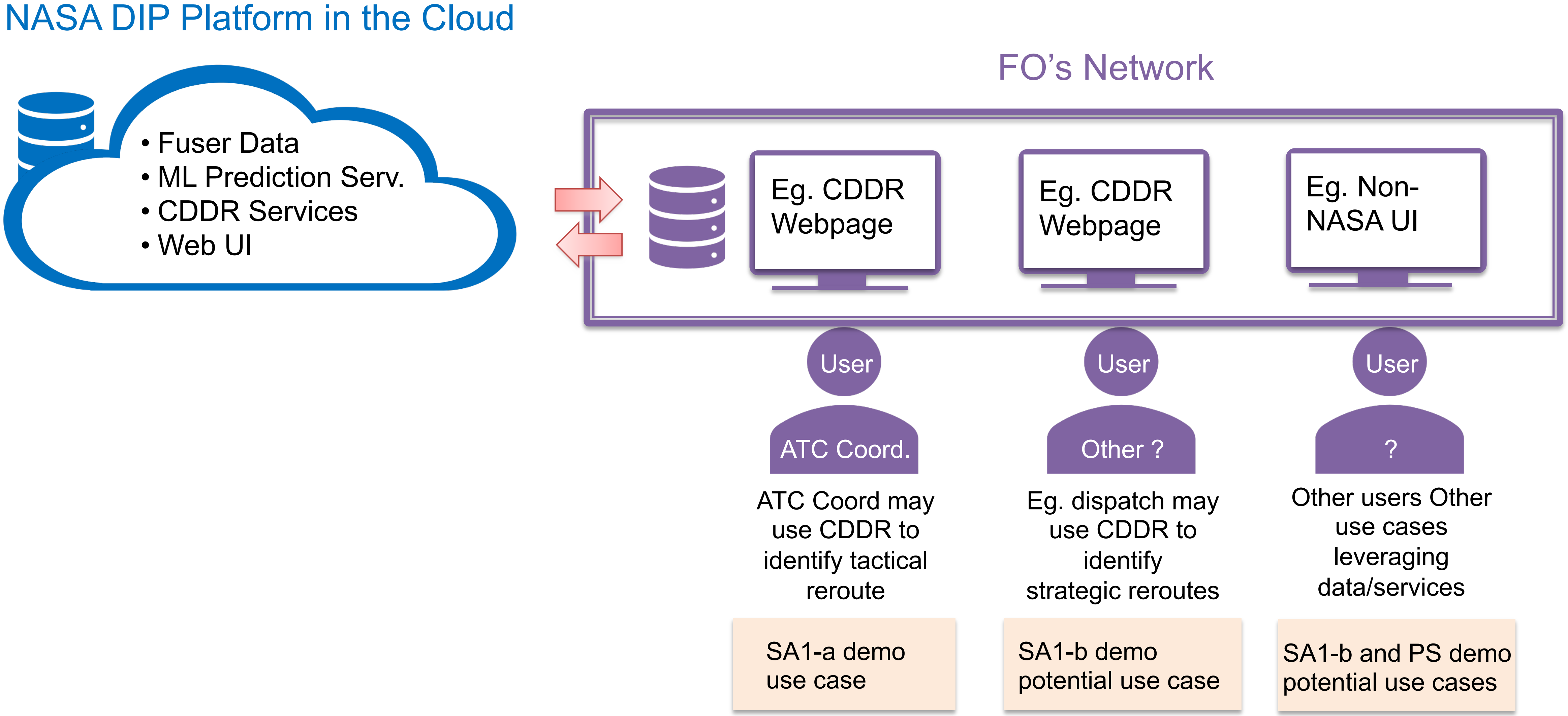
- CDDR cloud-based TOS table: prediction services write results to the backend system which show real-time data in cloud-based User Interface

- Consume real-time Fuser data: prediction services write results to the real-time Fuser data feed which can be consumed as pub/sub service

- Query data access API: prediction services write results to data archive which can be queried for near real-time or historical results

- Query model API: machine learning models can be queried in what-if mode where user provides required input and model returns the prediction

SA1 Capability For CDDR Partners in FY23 and Beyond



NASA DIP Platform in the Cloud

- Fuser Data
- ML Prediction Serv.
- CDDR Services
- Web UI

FO's Network

Eg. CDDR Webpage

Eg. CDDR Webpage

Eg. Non-NASA UI

ATC Coord may use CDDR to identify tactical reroute

Eg. dispatch may use CDDR to identify strategic reroutes

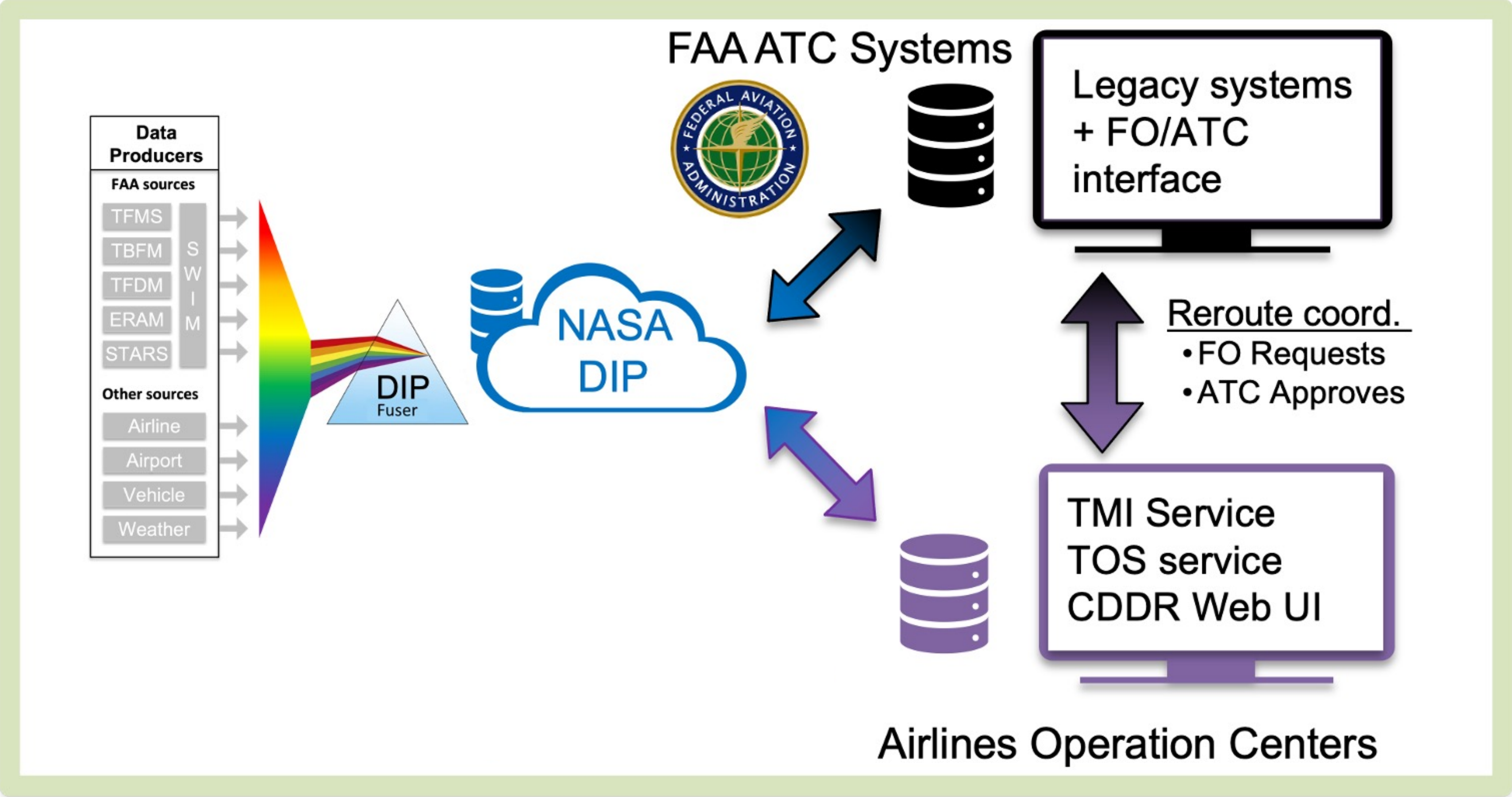
Other users Other use cases leveraging data/services

SA1-a demo use case

SA1-b demo potential use case

SA1-b and PS demo potential use cases

Flight Operator and ATC Coordination



FAA ATC Systems

Legacy systems
+ FO/ATC
interface

Reroute coord.
- FO Requests
- ATC Approves

TMI Service
TOS service
CDDR Web UI

Airlines Operation Centers

Example of User Interface: CDDR Webpage On Live System

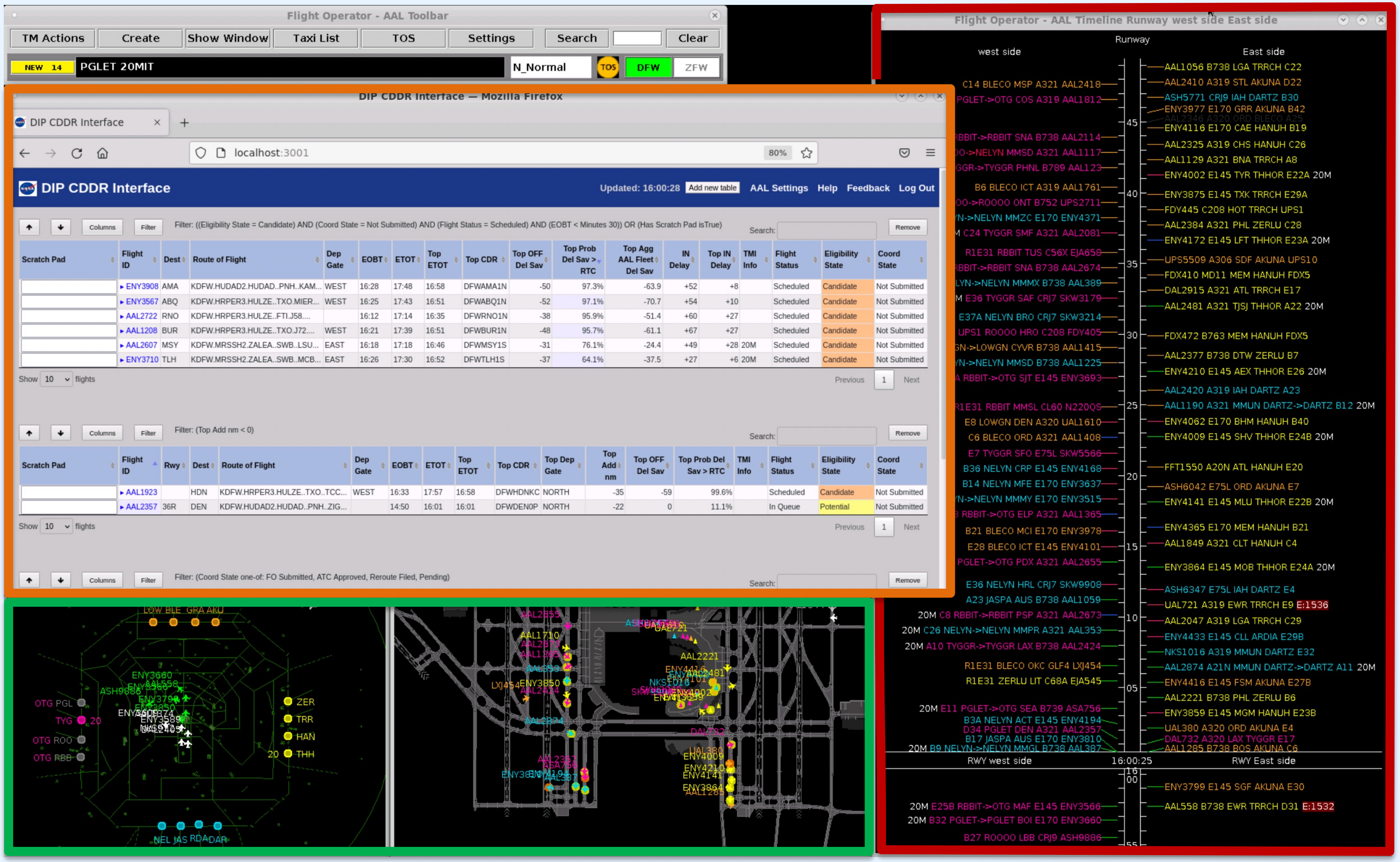
Current CDDR TOS Webpage And D-STBO Client For Flight Operators At North TX Facilities

FO side

CDDR's TOS Web Table UI

Displays:

- Flight data
- TOS
- Reroute opportunities



Filter: ((Eligibility State = Candidate) AND (Coord State = Not Submitted) AND (Flight Status = Scheduled) AND (EOBT < Minutes 30)) OR (Has Scratch Pad isTrue)

Scratch Pad	Flight ID	Dest	Route of Flight	Dep Gate	EOBT	ETOT	Top ETOT	Top CDR	Top OFF Del Sav	Top Prob Del Sav > RTC	Top Agg AAL Fleet Del Sav	IN Delay	Top IN Delay	TMI Info	Flight Status	Eligibility State	Coord State
	ENY3908	AMA	KDFW.HUDAD2.HUDAD..PNH..KAM...	WEST	16:28	17:48	16:58	DFWAMA1N	-50	97.3%	-63.9	+52	+8		Scheduled	Candidate	Not Submitted
	ENY3567	ABQ	KDFW.HRPER3.HULZE..TXO.MIER...	WEST	16:25	17:43	16:51	DFWABQ1N	-52	97.1%	-70.7	+54	+10		Scheduled	Candidate	Not Submitted
	AAL2722	RNO	KDFW.HRPER3.HULZE..FTI.J58....		16:12	17:14	16:35	DFWRNO1N	-38	95.9%	-51.4	+60	+27		Scheduled	Candidate	Not Submitted
	AAL1208	BUR	KDFW.HRPER3.HULZE..TXO.J72....	WEST	16:21	17:39	16:51	DFWBUR1N	-48	95.7%	-61.1	+67	+27		Scheduled	Candidate	Not Submitted
	AAL2607	MSY	KDFW.MRSSH2.ZALEA..SWB..LSU...	EAST	16:18	17:18	16:46	DFWMSY1S	-31	76.1%	-24.4	+49	+28	20M	Scheduled	Candidate	Not Submitted
	ENY3710	TLH	KDFW.MRSSH2.ZALEA..SWB..MCB...	EAST	16:26	17:30	16:52	DFWTLH1S	-37	64.1%	-37.5	+27	+6	20M	Scheduled	Candidate	Not Submitted

Filter: (Top Add nm < 0)

Scratch Pad	Flight ID	Rwy	Dest	Route of Flight	Dep Gate	EOBT	ETOT	Top ETOT	Top CDR	Top Dep Gate	Top Add nm	Top OFF Del Sav	Top Prob Del Sav > RTC	TMI Info	Flight Status	Eligibility State	Coord State
	AAL1923		HDN	KDFW.HRPER3.HULZE..TXO..TCC...	WEST	16:33	17:57	16:58	DFWHDNKC	NORTH	-35	-59	99.6%		Scheduled	Candidate	Not Submitted
	AAL2357	36R	DEN	KDFW.HUDAD2.HUDAD..PNH..ZIG...		14:50	16:01	16:01	DFWDEN0P	NORTH	-22	0	11.1%		In Queue	Potential	Not Submitted

Filter: (Coord State one-of: FO Submitted, ATC Approved, Reroute Filed, Pending)

```
west side
C14 BLECO MSP A321 AAL2418
PGLET->OTG COS A319 AAL1812
RBBIT->RBBIT SNA B738 AAL2114
OO->NELYN MMSD A321 AAL1117
GGR->TYGGR PHNL B789 AAL123
B6 BLECO ICT A319 AAL1761
OO->ROOOO ONT B752 UPS2711
YN->NELYN MMZC E170 ENY4371
M C24 TYGGR SMF A321 AAL2081
R1E31 RBBIT TUS C56X EJA658
RBBIT->RBBIT SNA B738 AAL2674
LYN->NELYN MMMX B738 AAL389
M E36 TYGGR SAF CRJ7 SKW3179
E37A NELYN BRO CRJ7 SKW3214
UPS1 ROOOO HRO C208 FDY405
GN->LOWGN CYVR B738 AAL1415
YN->NELYN MMSD B738 AAL1225
A RBBIT->OTG SJT E145 ENY3693
R1E31 RBBIT MMSL CL60 N220QS
E8 LOWGN DEN A320 UAL1610
C6 BLECO ORD A321 AAL1408
E7 TYGGR SFO E75L SKW5566
B36 NELYN CRP E145 ENY4168
B14 NELYN MFE E170 ENY3637
YN->NELYN MMMY E170 ENY3515
3 RBBIT->OTG ELP A321 AAL1365
B21 BLECO MCI E170 ENY3978
E28 BLECO ICT E145 ENY4101
PGLET->OTG PDX A321 AAL2655
E36 NELYN HRL CRJ7 SKW9908
A23 JASPA AUS B738 AAL1059
20M C8 RBBIT->RBBIT PSP A321 AAL2673
20M C26 NELYN->NELYN MMPR A321 AAL353
20M A10 TYGGR->TYGGR LAX B738 AAL2424
R1E31 BLECO OKC GLF4 LXJ454
R1E31 ZERLU LIT C68A EJA545
20M E11 PGLET->OTG SEA B739 ASA756
B3A NELYN ACT E145 ENY4194
D34 PGLET DEN A321 AAL2357
B17 JASPA AUS E170 ENY3810
20M B9 NELYN->NELYN MMGL B738 AAL387
20M E25B RBBIT->OTG MAF E145 ENY3566
20M B32 PGLET->PGLET BOI E170 ENY3660
B27 ROOOO LBB CRJ9 ASH9886

East side
AAL1056 B738 LGA TRRCH C22
AAL2410 A319 STL AKUNA D22
ASH5771 CRJ9 IAH DARTZ B30
ENY3977 E170 GRR AKUNA B42
AAL2346 A320 ORD BLECO A25
ENY4116 E170 CAE HANUH B19
AAL2325 A319 CHS HANUH C26
AAL1129 A321 BNA TRRCH A8
ENY4002 E145 TYR THHOR E22A 20M
ENY3875 E145 TXK TRRCH E29A
FDY445 C208 HOT TRRCH UPS1
AAL2384 A321 PHL ZERLU C28
ENY4172 E145 LFT THHOR E23A 20M
UPS5509 A306 SDF AKUNA UPS10
FDX410 MD11 MEM HANUH FDX5
DAL2915 A321 ATL TRRCH E17
AAL2481 A321 TJSJ THHOR A22 20M
FDX472 B763 MEM HANUH FDX5
AAL2377 B738 DTW ZERLU B7
ENY4210 E145 AEX THHOR E26 20M
AAL2420 A319 IAH DARTZ A23
AAL1190 A321 MMUN DARTZ->DARTZ B12 20M
ENY4062 E170 BHM HANUH B40
ENY4009 E145 SHV THHOR E24B 20M
FFT1550 A20N ATL HANUH E20
ASH6042 E75L ORD AKUNA E7
ENY4141 E145 MLU THHOR E22B 20M
ENY4365 E170 MEM HANUH B21
AAL1849 A321 CLT HANUH C4
ENY3864 E145 MOB THHOR E24A 20M
ASH6347 E75L IAH DARTZ E4
UAL721 A319 EWR TRRCH E9 E:1536
AAL2047 A319 LGA TRRCH C29
ENY4433 E145 CLL ARDIA E29B
NKS1016 A319 MMUN DARTZ E32
AAL2874 A21N MMUN DARTZ->DARTZ A11 20M
ENY4416 E145 FSM AKUNA E27B
AAL2221 B738 PHL ZERLU B6
ENY3859 E145 MGM HANUH E23B
UAL380 A320 ORD AKUNA E4
DAL732 A320 LAX TYGGR E17
AAL1285 B738 BOS AKUNA C6
ENY3799 E145 SGF AKUNA E30
AAL558 B738 EWR TRRCH D31 E:1532
```

D-STBO's Map

Displays:

- Flight position with datatag
- Fixes and restrictions

D-STBO's Timeline

Displays:

- Flight datatag
- Predicted times (eg. off times or and on times)

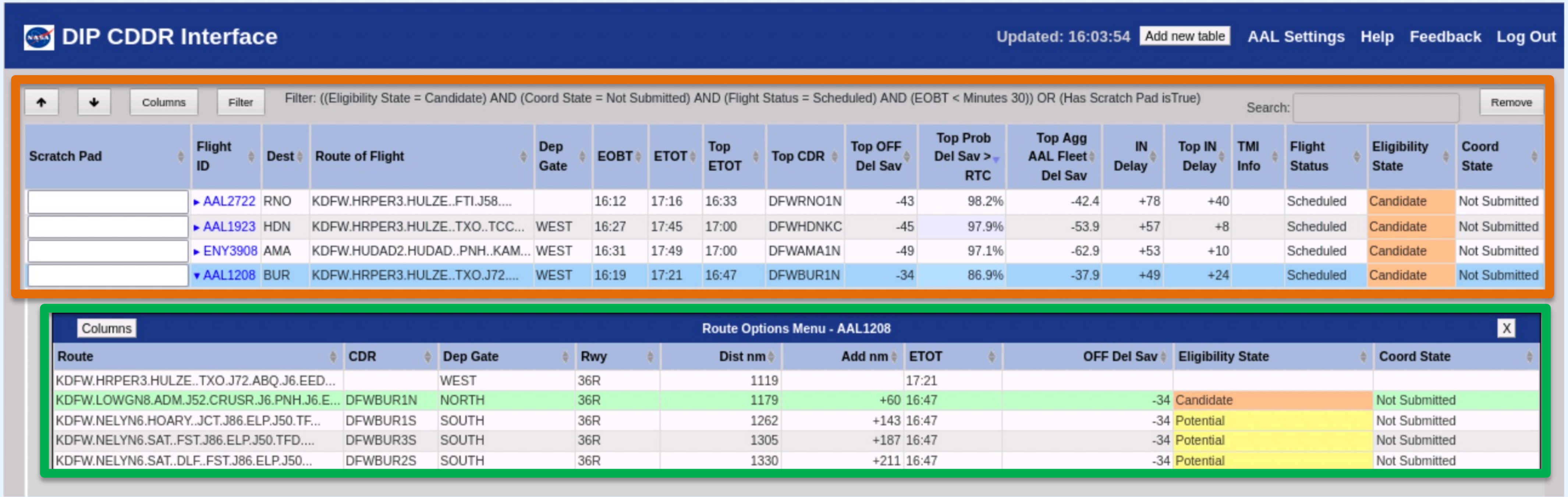
Note: D-STBO is not part of the CDDR web UI that will be accessible via DIP

CDDR Webpage – TOS Tables For Flight Operators

FO side

Main TOS Table displays (data fields can be tailored to each table):

- Scratchpad
- Flight data
- Flight state
- EOBT
- Best alternative route
- Relative Trajectory Cost (RTC hidden in this example)
- Alt rte OFF time
- Alt rte delay Savings
- Fleet Delay Savings if flight flew alt rte
- IN delay on filed rte
- IN delay savings on alt route
- TMIs on filed rte
- Alt rte eligibility status
- Alt rte coordination status



Filter: ((Eligibility State = Candidate) AND (Coord State = Not Submitted) AND (Flight Status = Scheduled) AND (EOBT < Minutes 30)) OR (Has Scratch Pad isTrue)

Scratch Pad	Flight ID	Dest	Route of Flight	Dep Gate	EOBT	ETOT	Top ETOT	Top CDR	Top OFF Del Sav	Top Prob Del Sav > RTC	Top Agg AAL Fleet Del Sav	IN Delay	Top IN Delay	TMI Info	Flight Status	Eligibility State	Coord State
	▸ AAL2722	RNO	KDFW.HRPER3.HULZE..FTI.J58....		16:12	17:16	16:33	DFWRNO1N	-43	98.2%	-42.4	+78	+40		Scheduled	Candidate	Not Submitted
	▸ AAL1923	HDN	KDFW.HRPER3.HULZE..TXO..TCC...	WEST	16:27	17:45	17:00	DFWHDNKC	-45	97.9%	-53.9	+57	+8		Scheduled	Candidate	Not Submitted
	▸ ENY3908	AMA	KDFW.HUDAD2.HUDAD..PNH..KAM...	WEST	16:31	17:49	17:00	DFWAMA1N	-49	97.1%	-62.9	+53	+10		Scheduled	Candidate	Not Submitted
	▾ AAL1208	BUR	KDFW.HRPER3.HULZE..TXO.J72....	WEST	16:19	17:21	16:47	DFWBUR1N	-34	86.9%	-37.9	+49	+24		Scheduled	Candidate	Not Submitted

Route Options Menu - AAL1208

Route	CDR	Dep Gate	Rwy	Dist nm	Add nm	ETOT	OFF Del Sav	Eligibility State	Coord State
KDFW.HRPER3.HULZE..TXO.J72.ABQ.J6.EED...		WEST	36R	1119		17:21			
KDFW.LOWGN8.ADM.J52.CRUSR.J6.PNH.J6.E...	DFWBUR1N	NORTH	36R	1179	+60	16:47	-34	Candidate	Not Submitted
KDFW.NELYN6.HOARY..JCT.J86.ELP.J50.TF...	DFWBUR1S	SOUTH	36R	1262	+143	16:47	-34	Potential	Not Submitted
KDFW.NELYN6.SAT..FST.J86.ELP.J50.TFD....	DFWBUR3S	SOUTH	36R	1305	+187	16:47	-34	Potential	Not Submitted
KDFW.NELYN6.SAT..DLF..FST.J86.ELP.J50...	DFWBUR2S	SOUTH	36R	1330	+211	16:47	-34	Potential	Not Submitted

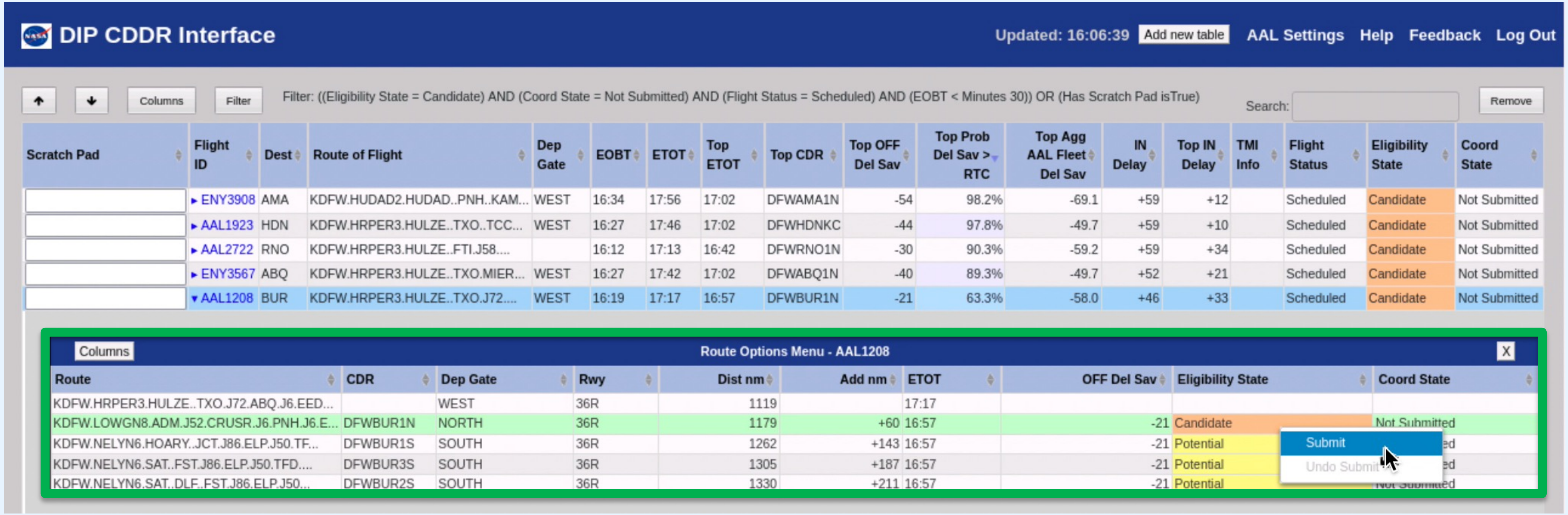
Flight Route Options Menu displays (data can be tailored as well):

- Filed route (first row): gate, runway, route distance, predicted off time
- Alternative routes (subsequent rows): CDR, dep gate, predicted runway, route distance, additional mileage, predicted off time, delay savings, eligibility state (candidate = delay savings > RTC, potential = delay savings < RTC), coordination state (indicate if route is submitted, approved, unable, reroute is filed, or excluded (due to TMIs)

FO Submits A Reroute Request For a Flight

FO side

1) FO right-clicks and submits a reroute request for an alternative route with benefits



DIP CDDR Interface

Updated: 16:06:39 | Add new table | AAL Settings | Help | Feedback | Log Out

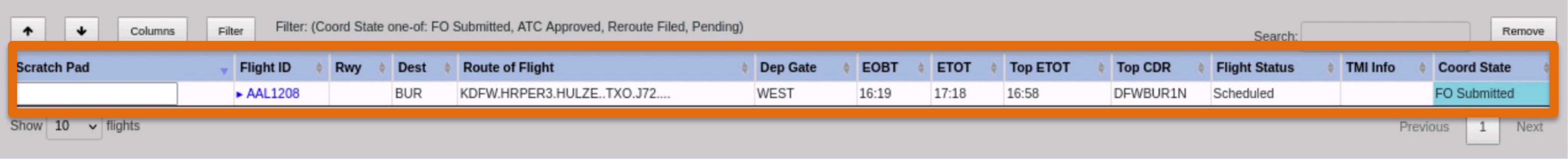
Filter: ((Eligibility State = Candidate) AND (Coord State = Not Submitted) AND (Flight Status = Scheduled) AND (EOBT < Minutes 30)) OR (Has Scratch Pad isTrue)

Scratch Pad	Flight ID	Dest	Route of Flight	Dep Gate	EOBT	ETOT	Top ETOT	Top CDR	Top OFF Del Sav	Top Prob Del Sav > RTC	Top Agg AAL Fleet Del Sav	IN Delay	Top IN Delay	TMI Info	Flight Status	Eligibility State	Coord State
	▸ ENY3908	AMA	KDFW.HUDAD2.HUDAD..PNH..KAM...	WEST	16:34	17:56	17:02	DFWAMA1N	-54	98.2%	-69.1	+59	+12		Scheduled	Candidate	Not Submitted
	▸ AAL1923	HDN	KDFW.HRPER3.HULZE..TXO..TCC...	WEST	16:27	17:46	17:02	DFWHDNKC	-44	97.8%	-49.7	+59	+10		Scheduled	Candidate	Not Submitted
	▸ AAL2722	RNO	KDFW.HRPER3.HULZE..FTI.J58....		16:12	17:13	16:42	DFWRNO1N	-30	90.3%	-59.2	+59	+34		Scheduled	Candidate	Not Submitted
	▸ ENY3567	ABQ	KDFW.HRPER3.HULZE..TXO.MIER...	WEST	16:27	17:42	17:02	DFWABQ1N	-40	89.3%	-49.7	+52	+21		Scheduled	Candidate	Not Submitted
	▾ AAL1208	BUR	KDFW.HRPER3.HULZE..TXO.J72....	WEST	16:19	17:17	16:57	DFWBUR1N	-21	63.3%	-58.0	+46	+33		Scheduled	Candidate	Not Submitted

Route Options Menu - AAL1208

Route	CDR	Dep Gate	Rwy	Dist nm	Add nm	ETOT	OFF Del Sav	Eligibility State	Coord State
KDFW.HRPER3.HULZE..TXO.J72.ABQ.J6.EED...		WEST	36R	1119		17:17			
KDFW.LOWGN8.ADM.J52.CRUSR.J6.PNH.J6.E...	DFWBUR1N	NORTH	36R	1179	+60	16:57	-21	Candidate	Not Submitted
KDFW.NELYN6.HOARY..JCT.J86.ELP.J50.TF...	DFWBUR1S	SOUTH	36R	1262	+143	16:57	-21	Potential	ed
KDFW.NELYN6.SAT..FST.J86.ELP.J50.TFD....	DFWBUR3S	SOUTH	36R	1305	+187	16:57	-21	Potential	ed
KDFW.NELYN6.SAT..DLF..FST.J86.ELP.J50...	DFWBUR2S	SOUTH	36R	1330	+211	16:57	-21	Potential	Not Submitted

2) A dedicated main TOS Table shows the route has been submitted



Filter: (Coord State one-of: FO Submitted, ATC Approved, Reroute Filed, Pending)

Scratch Pad	Flight ID	Rwy	Dest	Route of Flight	Dep Gate	EOBT	ETOT	Top ETOT	Top CDR	Flight Status	TMI Info	Coord State
	▸ AAL1208		BUR	KDFW.HRPER3.HULZE..TXO.J72....	WEST	16:19	17:18	16:58	DFWBUR1N	Scheduled		FO Submitted

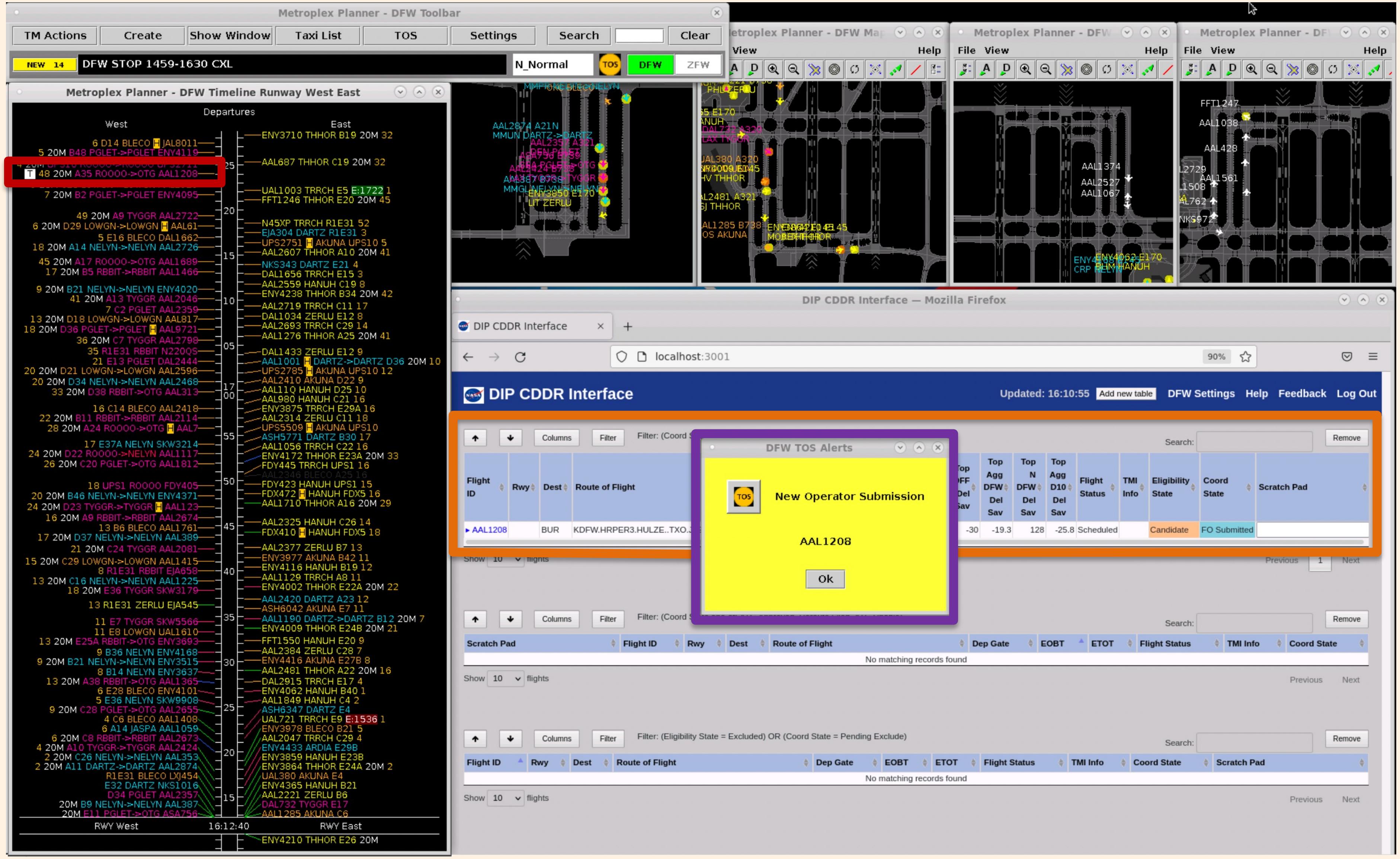
ATC Is Alerted Of Flight Operator's Reroute Request

ATC side

Timeline indicates flight with "T" submission

TOS table lists flights with submitted routes

TOS Alert pops up when a flight has a reroute request submitted



Metroplex Planner - DFW Toolbar

TM Actions | Create | Show Window | Taxi List | TOS | Settings | Search | Clear

NEW 14 DFW STOP 1459-1630 CXL | N_Normal | TOS | DFW | ZFW

Metroplex Planner - DFW Timeline Runway West East

Departures

West | East

T 48 20M A35 ROOOO->OTG AAL1208

RWY West 16:12:40 RWY East

DIP CDDR Interface — Mozilla Firefox

localhost:3001

DIP CDDR Interface — Updated: 16:10:55 — Add new table — DFW Settings — Help — Feedback — Log Out

Flight ID	Rwy	Dest	Route of Flight	Top OFF Del Sav	Top Agg DFW Del Sav	Top N DFW Del Sav	Top Agg D10 Del Sav	Flight Status	TMI Info	Eligibility State	Coord State	Scratch Pad
AAL1208		BUR	KDFW.HRPER3.HULZE..TXO.	-30	-19.3	128	-25.8	Scheduled		Candidate	FO Submitted	

DFW TOS Alerts

New Operator Submission

AAL1208

Ok

Scratch Pad	Flight ID	Rwy	Dest	Route of Flight	Dep Gate	EOBT	ETOT	Flight Status	TMI Info	Coord State
No matching records found										

Filter: (Eligibility State = Excluded) OR (Coord State = Pending Exclude)

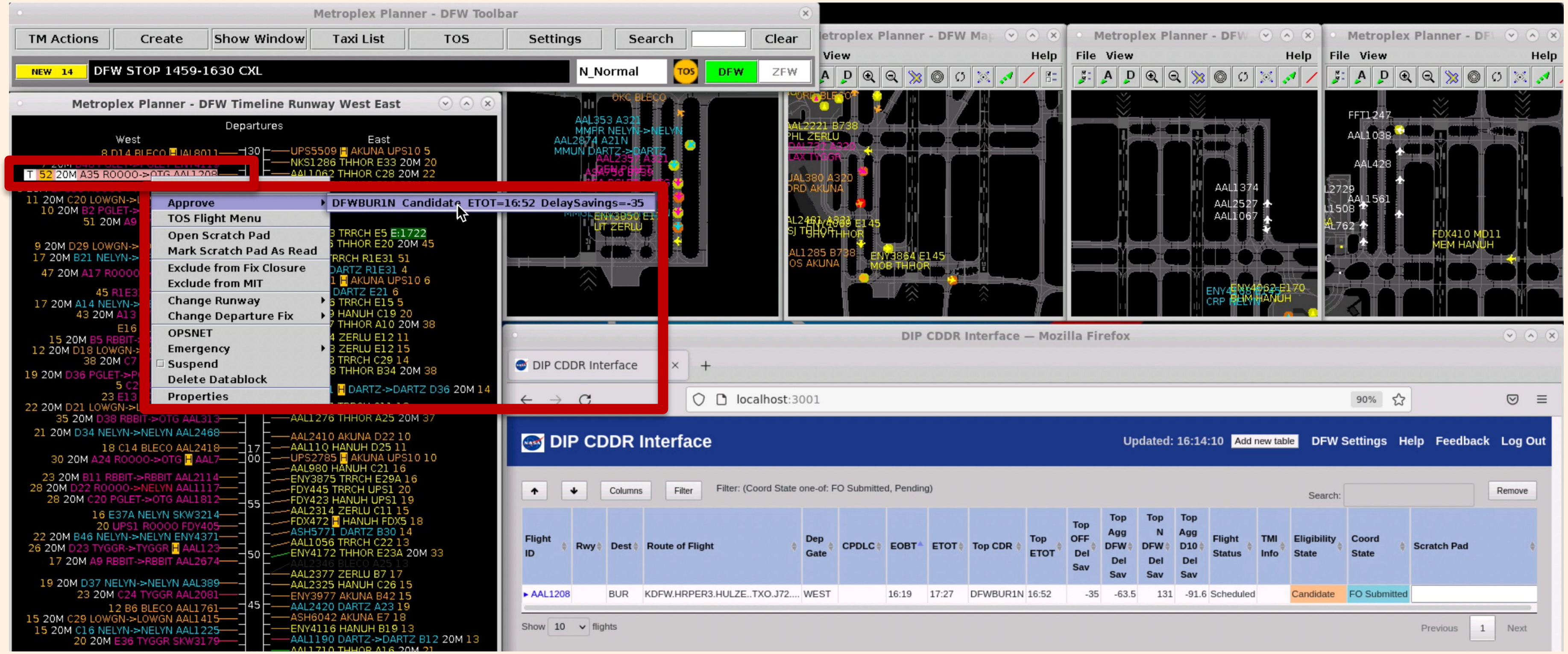
Flight ID	Rwy	Dest	Route of Flight	Dep Gate	EOBT	ETOT	Flight Status	TMI Info	Coord State	Scratch Pad
No matching records found										

ATC Approves FO's Reroute Request

ATC side

1) ATC right-clicks and "Approve" the reroute from STBO timeline (this can also be accomplished on the CDDR Web Tables)

Note: the ATC will then amend the filed route on the FDIO system using the CDR reference

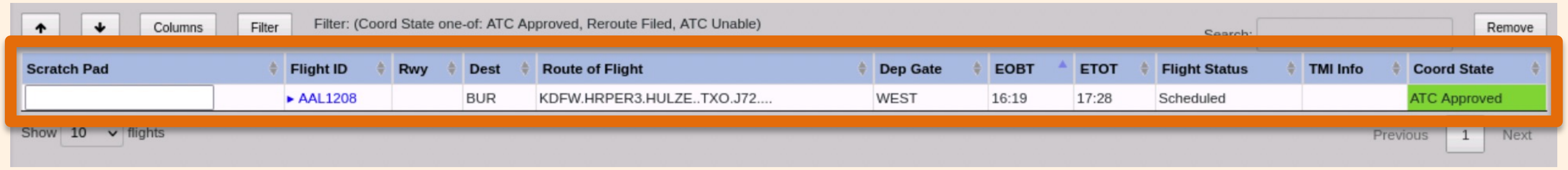


Filter: (Coord State one-of: FO Submitted, Pending)

Flight ID	Rwy	Dest	Route of Flight	Dep Gate	CPDLC	EOBT	ETOT	Top CDR	Top ETOT	Top OFF Del Sav	Top Agg DFW Del Sav	Top N DFW Del Sav	Top Agg D10 Del Sav	Flight Status	TMI Info	Eligibility State	Coord State	Scratch Pad
▸ AAL1208		BUR	KDFW.HRPER3.HULZE..TXO.J72....	WEST		16:19	17:27	DFWBUR1N	16:52	-35	-63.5	131	-91.6	Scheduled		Candidate	FO Submitted	

Show 10 flights   Previous 1 Next

2) Dedicated TOS table lists flights approved for reroutes



Filter: (Coord State one-of: ATC Approved, Reroute Filed, ATC Unable)

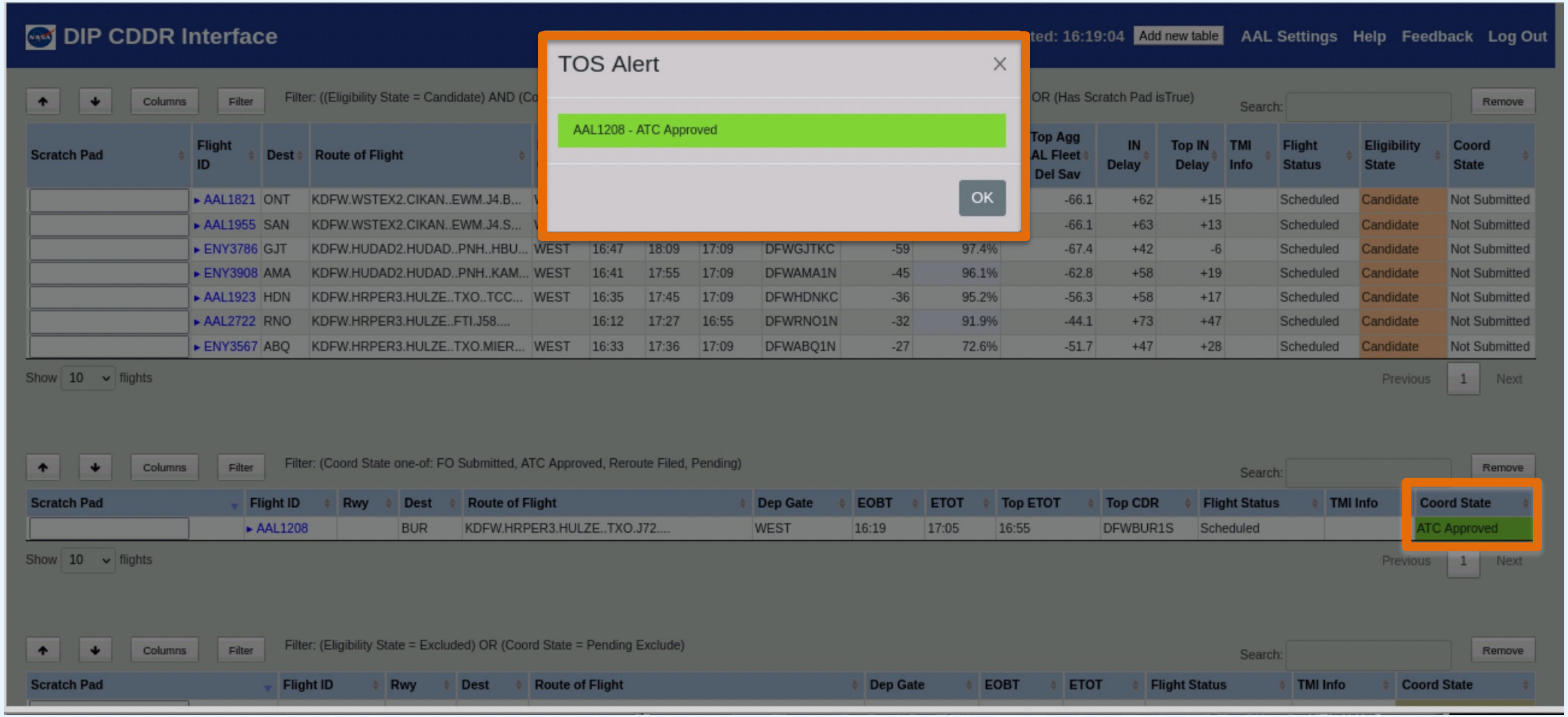
Scratch Pad	Flight ID	Rwy	Dest	Route of Flight	Dep Gate	EOBT	ETOT	Flight Status	TMI Info	Coord State
	▸ AAL1208		BUR	KDFW.HRPER3.HULZE..TXO.J72....	WEST	16:19	17:28	Scheduled		ATC Approved

Show 10 flights   Previous 1 Next

FO Is Alerted Of The Approval of the Reroute

FO side

The FO is alerted of the ATC approval



DIP CDDR Interface

ted: 16:19:04 | Add new table | AAL Settings | Help | Feedback | Log Out

TOS Alert

AAL1208 - ATC Approved

OK

Filter: ((Eligibility State = Candidate) AND (Co … OR (Has Scratch Pad isTrue)

Scratch Pad	Flight ID	Dest	Route of Flight								Top Agg AL Fleet Del Sav	IN Delay	Top IN Delay	TMI Info	Flight Status	Eligibility State	Coord State
	▸ AAL1821	ONT	KDFW.WSTEX2.CIKAN..EWM.J4.B...								-66.1	+62	+15		Scheduled	Candidate	Not Submitted
	▸ AAL1955	SAN	KDFW.WSTEX2.CIKAN..EWM.J4.S...								-66.1	+63	+13		Scheduled	Candidate	Not Submitted
	▸ ENY3786	GJT	KDFW.HUDAD2.HUDAD..PNH..HBU...	WEST	16:47	18:09	17:09	DFWGJTKC	-59	97.4%	-67.4	+42	-6		Scheduled	Candidate	Not Submitted
	▸ ENY3908	AMA	KDFW.HUDAD2.HUDAD..PNH..KAM...	WEST	16:41	17:55	17:09	DFWAMA1N	-45	96.1%	-62.8	+58	+19		Scheduled	Candidate	Not Submitted
	▸ AAL1923	HDN	KDFW.HRPER3.HULZE..TXO..TCC...	WEST	16:35	17:45	17:09	DFWHDNKC	-36	95.2%	-56.3	+58	+17		Scheduled	Candidate	Not Submitted
	▸ AAL2722	RNO	KDFW.HRPER3.HULZE..FTI.J58....		16:12	17:27	16:55	DFWRNO1N	-32	91.9%	-44.1	+73	+47		Scheduled	Candidate	Not Submitted
	▸ ENY3567	ABQ	KDFW.HRPER3.HULZE..TXO.MIER...	WEST	16:33	17:36	17:09	DFWABQ1N	-27	72.6%	-51.7	+47	+28		Scheduled	Candidate	Not Submitted

Show 10 flights — Previous 1 Next

Filter: (Coord State one-of: FO Submitted, ATC Approved, Reroute Filed, Pending)

Scratch Pad	Flight ID	Rwy	Dest	Route of Flight	Dep Gate	EOBT	ETOT	Top ETOT	Top CDR	Flight Status	TMI Info	Coord State
	▸ AAL1208		BUR	KDFW.HRPER3.HULZE..TXO.J72....	WEST	16:19	17:05	16:55	DFWBUR1S	Scheduled		ATC Approved

Show 10 flights — Previous 1 Next

Filter: (Eligibility State = Excluded) OR (Coord State = Pending Exclude)

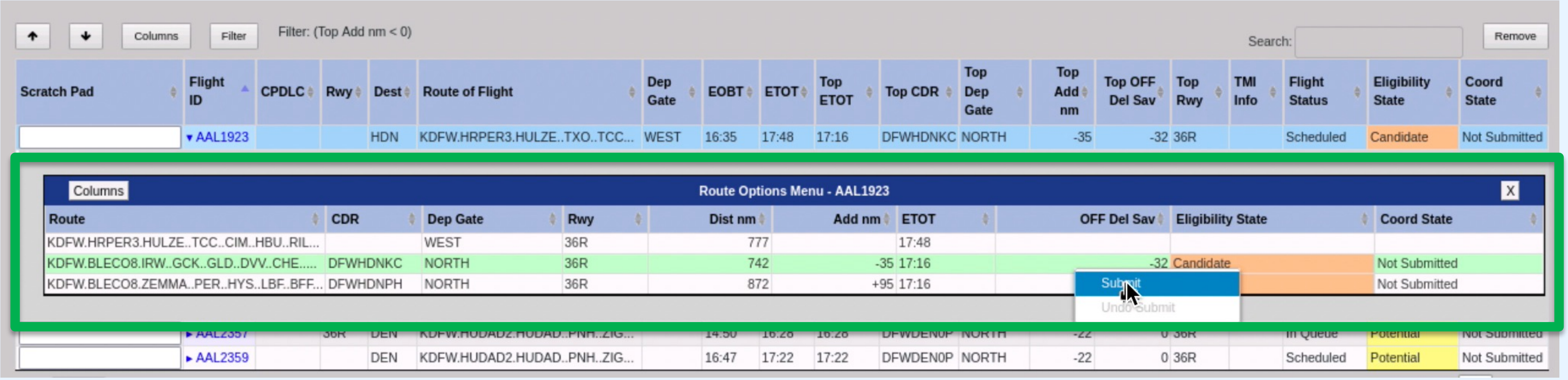
Scratch Pad	Flight ID	Rwy	Dest	Route of Flight	Dep Gate	EOBT	ETOT	Flight Status	TMI Info	Coord State

Later on, when the route is amended and in SWIM data, the system will detect the new route and updates the Coordination State to “Reroute Filed”

FO Submits Another Reroute Request For A Flight

FO side

1) FO right-clicks and submits an alternative route (alternative route is shorter than filed route)



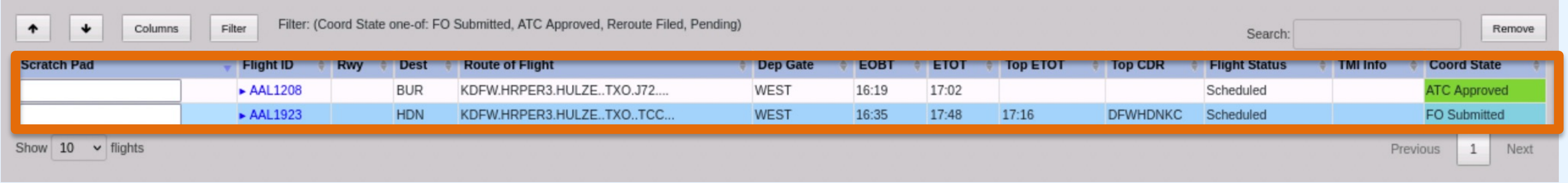
Filter: (Top Add nm < 0)

Scratch Pad	Flight ID	CPDLC	Rwy	Dest	Route of Flight	Dep Gate	EOBT	ETOT	Top ETOT	Top CDR	Top Dep Gate	Top Add nm	Top OFF Del Sav	Top Rwy	TMI Info	Flight Status	Eligibility State	Coord State
	▾ AAL1923			HDN	KDFW.HRPER3.HULZE..TXO..TCC...	WEST	16:35	17:48	17:16	DFWHDNKC	NORTH	-35	-32	36R		Scheduled	Candidate	Not Submitted
	▸ AAL2357		36R	DEN	KDFW.HUDAD2.HUDAD..PNH..ZIG...		14:50	16:28	16:28	DFWDEN0P	NORTH	-22	0	36R		In Queue	Potential	Not Submitted
	▸ AAL2359			DEN	KDFW.HUDAD2.HUDAD..PNH..ZIG...		16:47	17:22	17:22	DFWDEN0P	NORTH	-22	0	36R		Scheduled	Potential	Not Submitted

Route Options Menu - AAL1923

Route	CDR	Dep Gate	Rwy	Dist nm	Add nm	ETOT	OFF Del Sav	Eligibility State	Coord State
KDFW.HRPER3.HULZE..TCC..CIM..HBU..RIL...		WEST	36R	777		17:48			
KDFW.BLECO8.IRW..GCK..GLD..DVV..CHE.....	DFWHDNKC	NORTH	36R	742	-35	17:16	-32	Candidate	Not Submitted
KDFW.BLECO8.ZEMMA..PER..HYS..LBF..BFF...	DFWHDNPH	NORTH	36R	872	+95	17:16			Not Submitted

2) A dedicated main TOS Table shows the route has been submitted



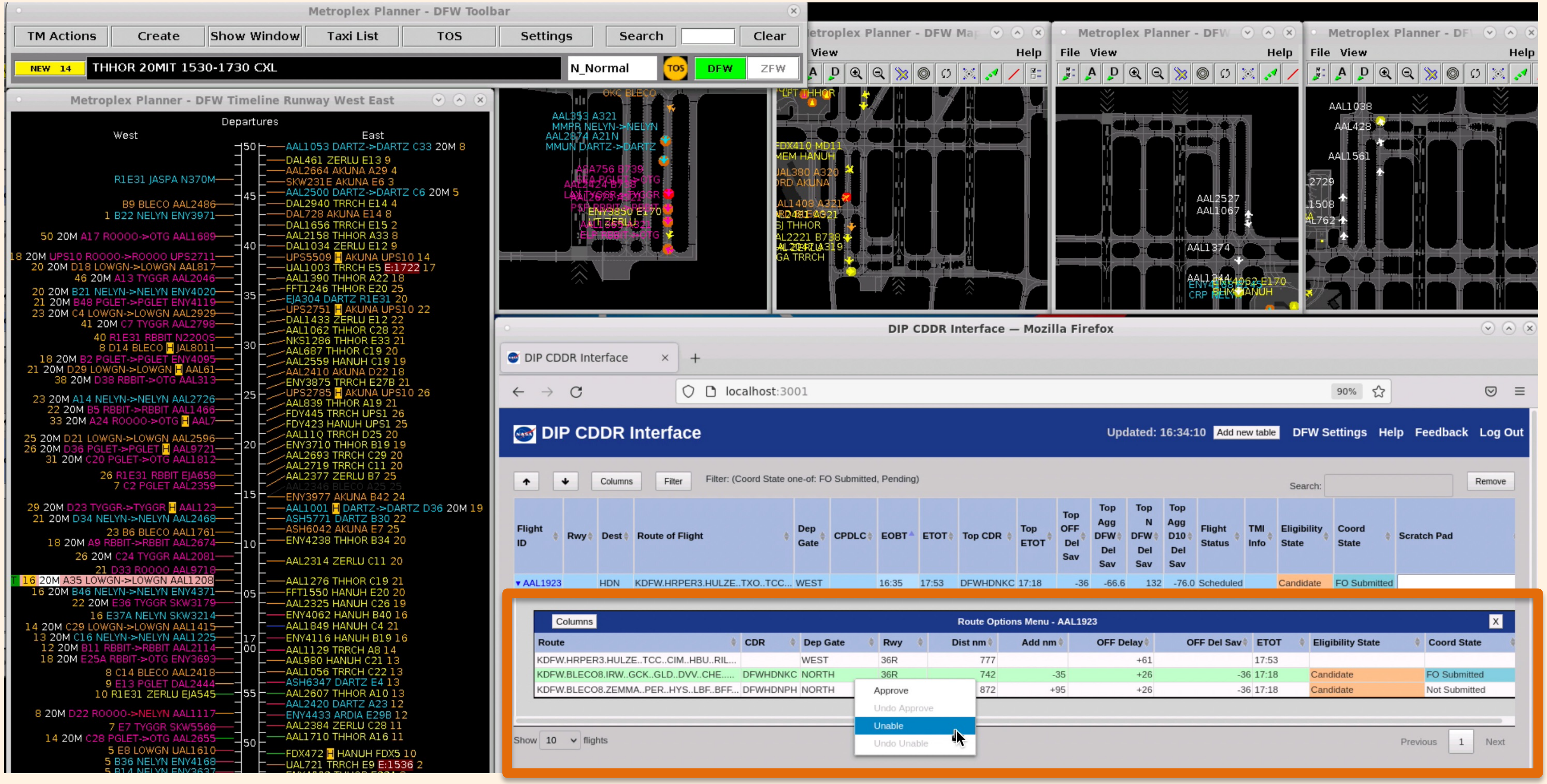
Filter: (Coord State one-of: FO Submitted, ATC Approved, Reroute Filed, Pending)

Scratch Pad	Flight ID	Rwy	Dest	Route of Flight	Dep Gate	EOBT	ETOT	Top ETOT	Top CDR	Flight Status	TMI Info	Coord State
	▸ AAL1208		BUR	KDFW.HRPER3.HULZE..TXO.J72....	WEST	16:19	17:02			Scheduled		ATC Approved
	▸ AAL1923		HDN	KDFW.HRPER3.HULZE..TXO..TCC...	WEST	16:35	17:48	17:16	DFWHDNKC	Scheduled		FO Submitted

ATC Does Not Approve FO's Reroute Request

ATC side

1) ATC right-clicks and "Unable" the reroute from the Web Table



DIP CDDR Interface

Updated: 16:34:10 Add new table DFW Settings Help Feedback Log Out

Columns Filter Filter: (Coord State one-of: FO Submitted, Pending) Search: Remove

Flight ID	Rwy	Dest	Route of Flight	Dep Gate	CPDLC	EOBT	ETOT	Top CDR	Top ETOT	Top OFF Del Sav	Top Agg DFW Del Sav	Top N DFW Del Sav	Top Agg D10 Del Sav	Flight Status	TMI Info	Eligibility State	Coord State	Scratch Pad
▾ AAL1923		HDN	KDFW.HRPER3.HULZE..TXO..TCC...	WEST		16:35	17:53	DFWHDNKC	17:18	-36	-66.6	132	-76.0	Scheduled		Candidate	FO Submitted	

Route Options Menu - AAL1923

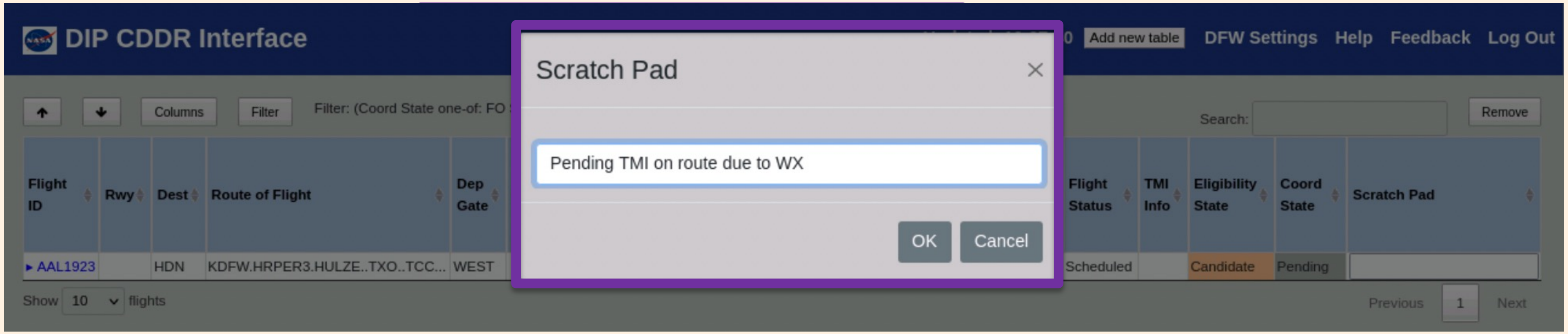
Route	CDR	Dep Gate	Rwy	Dist nm	Add nm	OFF Delay	OFF Del Sav	ETOT	Eligibility State	Coord State
KDFW.HRPER3.HULZE..TCC..CIM..HBU..RIL...		WEST	36R	777		+61		17:53		
KDFW.BLECO8.IRW..GCK..GLD..DVV..CHE.....	DFWHDNKC	NORTH	36R	742	-35	+26	-36	17:18	Candidate	FO Submitted
KDFW.BLECO8.ZEMMA..PER..HYS..LBF..BFF...	DFWHDNPH	NORTH		872	+95	+26	-36	17:18	Candidate	Not Submitted

Show 10 flights Previous 1 Next

ATC Makes A Scratchpad Entry

ATC side

1) Tower makes a scratchpad entry with some additional information for the flight they are not able to approve



Filter: (Coord State one-of: FO

Flight ID	Rwy	Dest	Route of Flight	Dep Gate	Flight Status	TMI Info	Eligibility State	Coord State	Scratch Pad
▸ AAL1923		HDN	KDFW.HRPER3.HULZE..TXO..TCC...	WEST	Scheduled		Candidate	Pending	

Scratch Pad ×

Pending TMI on route due to WX

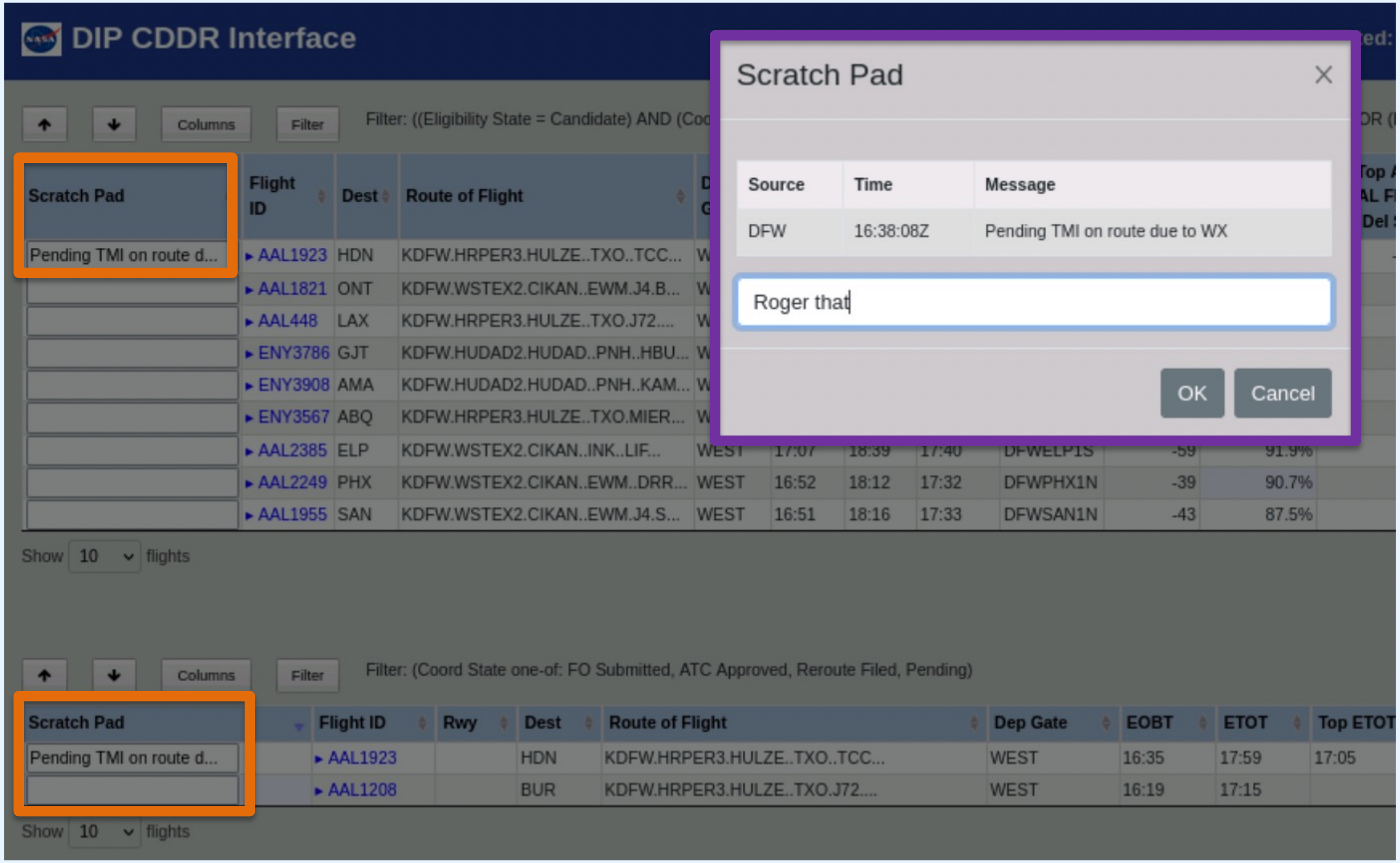
OK Cancel

FO Makes a Scratch Pad Entry to Respond to ATC

FO side

1) The scratchpad entry appears in the TOS Table

2) FO can open the scratchpad and respond to the tower to acknowledge the message



DIP CDDR Interface

Filter: ((Eligibility State = Candidate) AND (Coo

Scratch Pad	Flight ID	Dest	Route of Flight	D G							Top A AL F Del
Pending TMI on route d...	▸ AAL1923	HDN	KDFW.HRPER3.HULZE..TXO..TCC...	W							-
	▸ AAL1821	ONT	KDFW.WSTEX2.CIKAN..EWM.J4.B...	W							
	▸ AAL448	LAX	KDFW.HRPER3.HULZE..TXO.J72....	W							
	▸ ENY3786	GJT	KDFW.HUDAD2.HUDAD..PNH..HBU...	W							
	▸ ENY3908	AMA	KDFW.HUDAD2.HUDAD..PNH..KAM...	W							
	▸ ENY3567	ABQ	KDFW.HRPER3.HULZE..TXO.MIER...	W							
	▸ AAL2385	ELP	KDFW.WSTEX2.CIKAN..INK..LIF...	WEST	17:07	18:39	17:40	DFWELP1S	-59	91.9%	
	▸ AAL2249	PHX	KDFW.WSTEX2.CIKAN..EWM..DRR...	WEST	16:52	18:12	17:32	DFWPHX1N	-39	90.7%	
	▸ AAL1955	SAN	KDFW.WSTEX2.CIKAN..EWM.J4.S...	WEST	16:51	18:16	17:33	DFWSAN1N	-43	87.5%	

Show 10 flights

Scratch Pad ×

Source	Time	Message
DFW	16:38:08Z	Pending TMI on route due to WX

Roger that

Filter: (Coord State one-of: FO Submitted, ATC Approved, Reroute Filed, Pending)

Scratch Pad		Flight ID	Rwy	Dest	Route of Flight	Dep Gate	EOBT	ETOT	Top ETOT
Pending TMI on route d...		▸ AAL1923		HDN	KDFW.HRPER3.HULZE..TXO..TCC...	WEST	16:35	17:59	17:05
		▸ AAL1208		BUR	KDFW.HRPER3.HULZE..TXO.J72....	WEST	16:19	17:15	

Show 10 flights

Accuracy Metrics

Jeremy Coupe

william.j.coupe@nasa.gov

Accuracy Metrics for NASA Prediction Services

NASA developed a variety of predictive models to support CDDR and wants to assess the performance

Use Cases:

1. Understanding system performance
2. Evaluating model drift
3. Comparing against other modeling approaches

Example performance metrics:

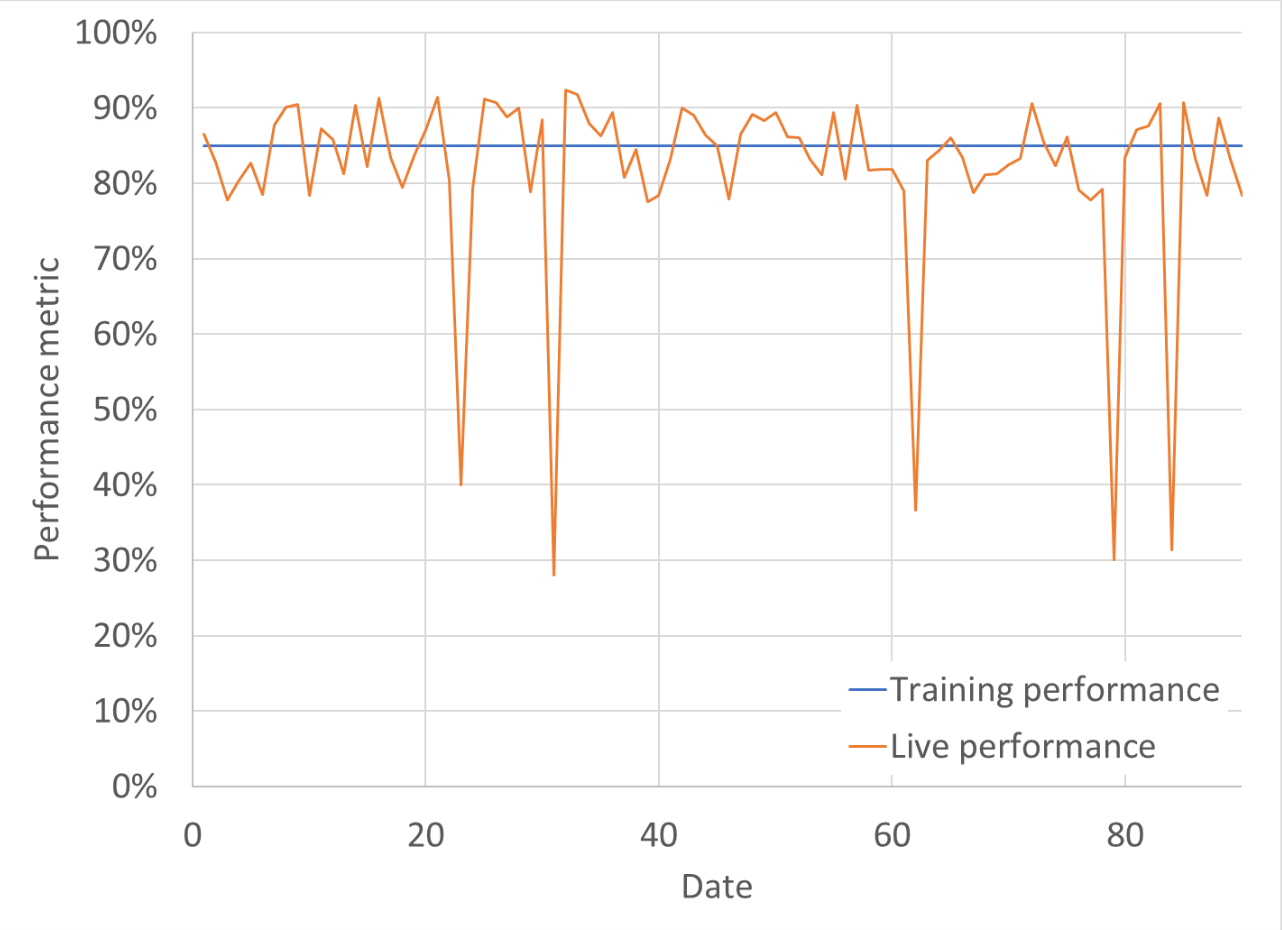
- Classification: accuracy, precision, recall
- Regression: mean absolute percent error, percent within +/- X minutes
- Groupings: all flights, flights with correct upstream inputs

Use Case: Understanding Model Performance

- ML models support field demonstration, so it is critical to understand if performance is *good enough* to enable user decision making

- Helps identify 'blips' in performance
  - Example: on day X, arrival runway prediction accuracy dropped from its normal level of 85% to 40%. What caused this? Was accuracy reduced all day long, or for some period of the day?

- Short-term monitoring essential for diagnostic purposes but sometimes surfaces transient behavior

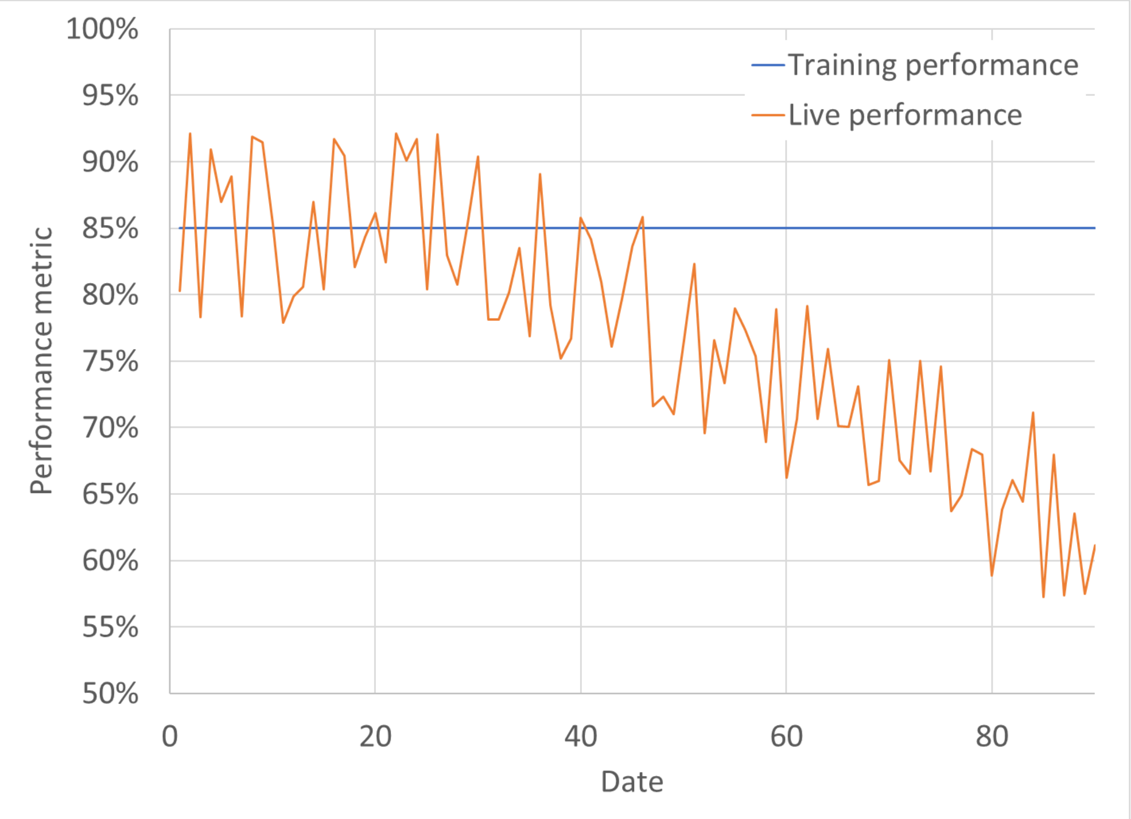


Use Case: Evaluating Model Drift

- Models trained using historical data – effectively learn dominant relationships present during that time period

- These relationships may change over time, yielding reduction in performance (e.g., reduced accuracy)
  - Example: taxiway X is closed for long-term maintenance beginning on day Y, increasing taxi times

- Formal methods exist for evaluating model drift, but also need visualizations to help understand trends

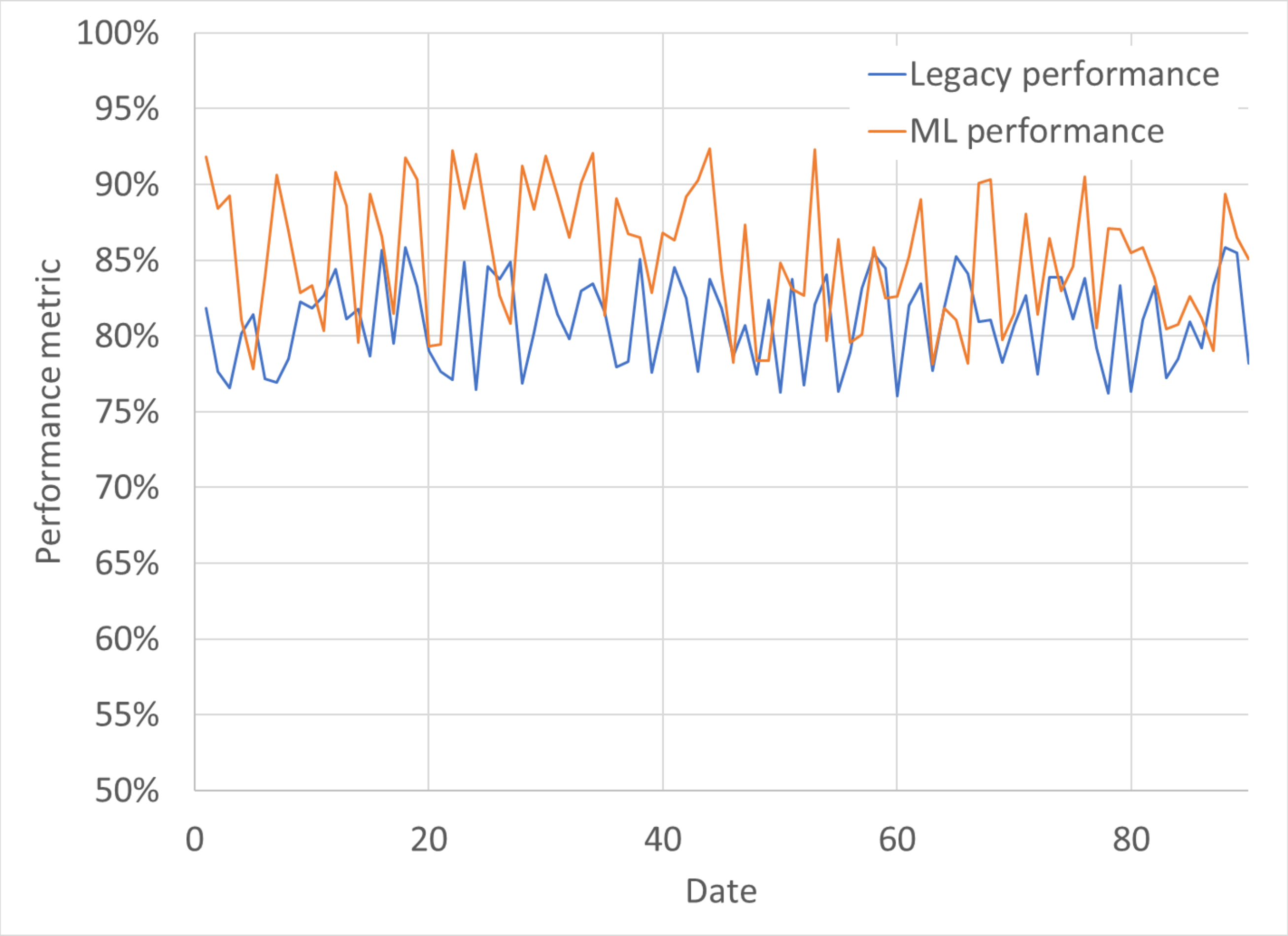


Use Case: Comparing Modeling Approaches

- Part of research agenda is to understand performance of ML approaches *in comparison to legacy adaptation-based approaches*

- Similar predictive functions performed in each, using different methodology, so that metrics can be compared

- Building drill-down capabilities may help facilitate identification of conditions under which each approach performs better



Catalog Service Accuracy Metrics

- Offline Accuracy: Long term accuracy metrics typically generated from offline testing and validation

- Online Accuracy: Accuracy metrics for models intended to run in real-time computed over the past calendar month

- Accuracy of Inputs: For real-time applications many of the inputs can be predictions from upstream models and the metrics should provide visibility into the quality of inputs and the impact to performance

Departure Runway Prediction: DFW

DFW Departure Runway Model	**Classification Metrics**	
	Count	Accuracy (percent correct)
Offline overall		88.8%
Online overall	23204	88.4%
Online, all inputs correct	14231 (61.3%)	91.6%
Online, any inputs incorrect	8823 (38.0%)	84.0%
Online, default response	81 (0.3%)	45.7%
Online, runway replaced (out of config)	69 (0.3%)	52.2%

Unimpeded AMA Taxi OUT: DFW

DFW Unimpeded AMA Taxi Out	Regression Metrics	
	Count	Accuracy (MAD in seconds)
Offline overall		35.6
Online overall	25821	47.4
Online, all inputs correct	18656 (72.3%)	35.6
Online, any inputs incorrect	2971 (11.5%)	143.8
Online, default response	4194 (16.2%)	185.3

Unimpeded AMA Taxi IN: DFW

DFW Unimpeded AMA Taxi In	Regression Metrics	
	Count	Accuracy (RMSE in seconds)
Offline overall		206.8
Online overall	24535	216.8
Online, all inputs correct	6453 (26.3%)	149.0
Online, any inputs incorrect	6385 (26.0%)	235.3
Online, default response	11697 (47.7%)	236.9

- Capturing accuracy grouped by correct/incorrect input and default response exposes issues in both the model and the underlying infrastructure feeding the model

Technical Plan and Schedule

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Pallavi Hegde
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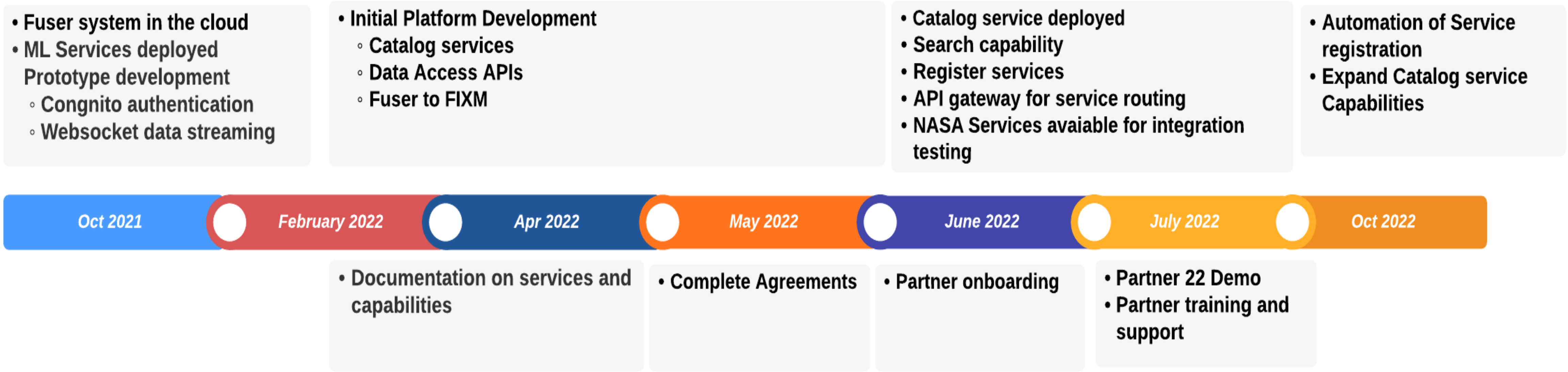
Preliminary Technical Plan and Schedule



- Fuser system in the cloud
- ML Services deployed Prototype development
  - Congnito authentication
  - Websocket data streaming

- Initial Platform Development
  - Catalog services
  - Data Access APIs
  - Fuser to FIXM

- Catalog service deployed
- Search capability
- Register services
- API gateway for service routing
- NASA Services avaiable for integration testing

- Automation of Service registration
- Expand Catalog service Capabilities

- Documentation on services and capabilities

- Complete Agreements

- Partner onboarding

- Partner 22 Demo
- Partner training and support

Questions and Answers

Please post your questions either in the chat box or the Conferences.io link https://arc.cnf.io/sessions/nedn/#!/dashboard

You are encouraged to answer additional questions from us in the same link

Next Steps and Closing Remarks

Mirna Johnson

mirna.g.johnson@nasa.gov

Contact Info

- Schedule
  - – Flight Operator Announcement for Collaborative Opportunity: TBD
  - – Service Provider Announcement for Collaborative Opportunity: TBD

- Please email to ARC-DIP-EXT@mail.nasa.gov for questions or comments

- Visit https://nari.arc.nasa.gov/atmx-dip for more information regarding DIP sub-project and future events

Thank you!